AMERICAN ENGINEER AND RAILROAD JOURNAL

NEW YORK [ETC.]

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(Established 1832.)

AMERICAN ENGINEER AND RAILROAD JOURNAL.

[Formerly the RAILROAD AND ENGINEERING JOURNAL.]

The AMERICAN RAILROAD JOURNAL and VAN NOSTRAND'S ENGINEERING MAGAZINE have been consolidated in this publication.

VOLUME LXVII.

[VOLUME VII, NEW SERIES.]

1893.

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INDEX.

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ILLUSTRATIONS.

ILLUSTRATIONS.

EDITORIALS.

EDITORIALS.

NEW PUBLICATIONS.

NEW PUBLICATIONS.

MISCELLANEOUS ARTICLES.

MISCELLANEOUS ARTICLES.

PERSONAL NOTES.

NOTES AND NEWS.

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THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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NEW YORK, JANUARY, 1893.

ANNOUNCEMENT.

WITH the present number, the first of the volume for 1893, the title of the RAILROAD AND ENGINEERING JOURNAL, under which it has been published since 1887—when the old *American Railroad Journal* and *Van Nostrand's Engineering Magazine* were consolidated—is changed to THE AMERICAN ENGINEER AND RAILROAD JOURNAL.

The chief reason for making this change is that the former title is somewhat cumbrous, is lacking in definiteness, and is not easily remembered. It has been found that many persons familiar with the JOURNAL, and even those who are regular readers of the paper, do not readily recall its name, and that it is often difficult to identify it by its title alone. At the time of the consolidation of its progenitors the name which would have been preferred to any other, for the new publication, was THE AMERICAN ENGINEER, but at that time a paper with that title was published in Chicago. Since then it has been discontinued, and therefore the name could be assumed by us if we were disposed to adopt it. For the reasons given it has been determined to make use of that privilege; and although a change in the title of a periodical publication is attended with obvious—but, it is thought, merely temporary—disadvantages, it is believed that they are not so great as the detriment resulting from the continued use of a name which is not sufficiently distinctive and is difficult to recall.

It must be understood, however, that the change of name does not imply any change of control; nothing but the title of our late cotemporary has been adopted, and the ownership and the editorial staff of the paper will continue the same as heretofore.

The new name will indicate distinctly the character which this publication is intended to have. It was announced in the first number of the RAILROAD AND ENGINEERING JOURNAL that it "will be devoted to the discussion of engineering and mechanical subjects. Railroad construction and operation being, however, the most important branches of engineering in this country, more space will be devoted to them than to any other one department of engineering." The general scope of the paper under its new title will not be materially changed. Its form and size will remain the same, but new type and a quality of paper better suited for the printing of process engravings will be used. It is intended to have a larger proportion of original articles than heretofore, and to make material improvements in the character of the illustrations published.

Among the articles already provided for, it may be mentioned that Dr. Dudley's interesting series of Contributions on Practical Railroad Information will be continued; and Mr. Chanute's on Progress in Flying Machines will also be continued and concluded. Fully illustrated descriptions of locomotives, cars, stationary and marine engines, shop appliances and practice by different builders will be given from time to time.

A series of articles on what may be called Comparative Anatomy of English and American Locomotives is commenced in the present number. These will be illustrated by very complete detailed engravings showing the construction of the engines and of the different parts or organs of the most recent express locomotives built for the London & Southwestern Railway, and of the engine with 7-ft. driving-wheels now running on the New York Central & Hudson River Railroad, an illustration of which was given in the November number. These illustrations will be fully described in critical articles comparing the construction and performance of both engines. This discussion will be continued through the greater part of the year 1893, and will, it is thought, give a better idea of the peculiarities of construction of both English and American locomotives than it is possible to obtain from any existing source.

Other new features will be added to the paper from time to time, and it will be the aim of its editors and proprietor to make the rechristened paper such a record of the work of THE AMERICAN ENGINEER as shall be a warrant for the use of that title.

EDITORIAL NOTES.

THE report of the Interstate Commerce Commission, which has just been presented to Congress, shows that the work of the Commission has been well continued. A large number of cases have been passed upon, and the report gives some idea of the great amount of detail work required in carrying out the law. Some important questions have arisen during the year, and in several cases references to the courts have been required. The Commission is decidedly a working body, and as little delay as possible is allowed in its decisions.

THE work of the Commission has brought about many changes in the way of equalizing rates and removing discriminations. This is a result of the law which is generally appreciated, and has done much toward securing public support for it. The regulation or fixing of rates is not within the powers of the Commission, but unjust discrimination and unequal charges can be prevented, and the action taken under the law has been steadily directed to that end.

SOME reference has heretofore been made to the statistical work done under direction of the Commission and its value. The report refers to this, and to the improvements which are looked for in future work of this class.

Some important amendments to the law are pending, chiefly in the direction of increasing the powers of the Commission in securing information and in enforcing its decisions. The weak points have been shown by experience, and the amendments recommended are chiefly in the direction of making the law more complete.

REPORTS come from Russia of some trials of armor-plates, in which the methods adopted at Annapolis and Indian Head seem to have been quite closely followed. The results were not favorable for the English Brown plates, which were badly shattered, while the Cammell plates also suffered severely, although one of the latter almost succeeded in passing the test. The best results were obtained with plates from the St. Chamond Works, in France. One of these, it is said, is reserved for a further test in competition with an American steel plate treated by the Harvey process.

REFERENCE was made in our issue of April last to an experiment with a closed cylinder, representing a section of the 5-in. Brown wire-wound gun. A maximum recorded pressure of nearly 54,000 foot-pounds failed to burst the cylinder; but reasons for declining to accept this test as conclusive of the endurance of the finished gun were given at some length.

On December 3 three shots were fired from a completed gun, or, rather, from a gun which had reached the stage of being rough bored. Charges of 10 lbs., 15 lbs. and 18 lbs. of sphero-hexagonal powder behind an 84-lbs. projectile were used. For the second and third shots pressures of something over 28,000 and 60,000 lbs. per square inch respectively are reported. The gun was uninjured. In view of the often erratic behavior of pressure-gauges, however, we can be pardoned for hesitating to accept the record of a single shot as proving this gun superior to any other heretofore known, the ordnance expert to the contrary notwithstanding.

THE SIBERIAN RAILROAD.

IN the JOURNAL for March, 1891, it was stated that the surveys for the Oussouri Section of the Great Siberian Railroad were made in 1887 and 1888. This is the extreme eastern section, connecting the line with its terminus on the Pacific.

In the spring of 1891 work on this section was formally begun, the occasion being marked by the presence of the Czarevitch Nicholas. It was then decided that this section should be built from the port of Vladivostok to Grafskaia on the Oussouri, a distance of 256 miles; and that surveys should be made for an extension of 200 miles from Grafskaia to Khabarovka, the administrative capital of the province.

But little work, however, has been accomplished during the seasons of 1891 and 1892. According to recent advices from St. Petersburg the work has been scattered over the first 160 miles, the grading at some points being completed, but at others hardly begun. About half of the earthwork —or 4,500,000 cubic yards—is completed, but the half remaining to be done is in a marshy and difficult country. Tracklaying was begun in September, but only 8 miles have been completed.

The working force employed consisted of about 3,000 soldiers and an equal number of convicts and exiles. A few Chinese and Coreans were employed for a time, but they did not prove satisfactory, being hardly strong enough, and the prisoners formed the main working force. After finishing the heavier earthwork of the first section, they are now employed in building the road through the great *taiga* or forest, about 150 miles from Vladivostok, where the convict administration has concentrated its force.

The tracklaying from Vladivostok to Nikolsk, the first important station—a distance of 66 miles—can hardly be finished before next fall.

The first cause of delay was the wreck in the Suez Canal of the German steamer *Triton*, which had on board six locomotives and a large quantity of rails, which should have been delivered to the road last spring. After much delay it was only in October last that the locomotives were finally recovered and forwarded on the steamer *Kostroma*.

Another correspondent says that there is still much unfinished work. A few section-houses have been built, but nothing has been done on the stations, and only the foundations of the terminal buildings at Vladivostok have been built.

At the beginning of 1891 the work was placed in charge of Chief Engineer Ursatti. He unfortunately became involved in misunderstandings with Baron Korff, the Governor-General of the Amour territory. This trouble culminated in the sending out of a commission of investigation, at the head of which was Mr. O. P. Viazemski, who was finally, in October last, appointed Chief Engineer in charge of construction, Mr. Ursatti being removed.

The new Chief Engineer, Mr. Viazemski, is well known in Russia as a civil engineer of ability. He had charge of the surveys of the Trans-Baikal section of the Siberian road and of the Baikal loop line, and is thoroughly acquainted with Eastern Siberia. He is, moreover, a personal friend of the Governor-General, Baron Korff, and will work in harmony with him. It is hoped that under his control the construction of the Oussouri Railroad will be quickly completed.

Still later advices give the official programme adopted by the Ministry of Lines of Communication, which provides for the construction of the entire line from Chelabinsk to Vladivostok in 12 years; the distance being 7,350 versts, or 4,900 miles. It is proposed to use for the present steam ferries at the crossings of the Irtish, the Obi, the Yenisei and the Amour, the building of the great bridges over these rivers being postponed until later.

In the season of 1893 work will be in progress on the following lines:

1. The Western Siberian Line, from Chelabinsk to the Obi River, 1,328 versts—885 miles—under charge of Chief Engineer Mikhailovski.

2. The Central Siberian Line, from the Obi River to Irkoutsk, 1,754 versts—1,170 miles—under charge of Chief Engineer Mejininov.

3. The Ekaterinburg-Mias Branch of 238 versts—159 miles—which will connect the Oural Railroad with the systems of European Russia. This will also be under the charge of Mr. Mikhailovski.

This official programme names the dates for completion of the several sections of the line as follows:

1. In 1894 the Oussouri Line, from Vladivostok to Grafskaia and the Ekaterinburg-Mias Branch.

2. In 1896 the main line from Chelabinsk to Krasnoiarsk, including the entire Western Siberian Line and a portion of the Central section.

3. In 1900 the remainder of the Central Siberian Line from Krasnoiarsk to Irkoutsk, and the extension of the Oussouri Line from Grafskaia to Khabarovka.

4. Finally, in 1904, the remainder of the main line from

Irkoutsk to Khabarovka, including the Baikal loop, the Trans-Baikal Line and the Amour Line. The last named has not yet been located.

It will be of interest to give the estimated cost of the line as now presented by the engineers :

Section.	Length.	Estimated Cost.
	Miles.	
Western Siberian:		
Chelabinsk to the Obi River..............	[illegible]	[illegible]
Central Siberian:		
Obi River to Irkoutsk	1,110	40,200,000
Baikal Loop:		
Around Lake Baikal........................	194	13,200,000
Trans-Baikal:		
Lake Baikal to Sretensk..................	663	32,400,000
Amour Line:		
Sretensk to Grafskaia	1,600	76,300,000
Oussouri Line:		
Grafskaia to Vladivostok....................	252	10,800,000
Total, Chelabinsk to the Pacific	4,703	$195,600,000

This estimate, which gives an average of $41,600 per mile, includes sufficient equipment for a light traffic. The most expensive section is the Baikal loop, which requires some very heavy work, as noted in our earlier accounts of the surveys.

It will be seen that the Ministry has given up the original plan of using water lines as part of the route, and has now finally decided in favor of the building of the continuous rail line.

We may add that the Zlatooust-Chelabinsk Railroad, which connects the Russian railroads with Chelabinsk, the starting-point of the Siberian Line, was formally opened for traffic in October.

THE HORSE-POWER OF A LOCOMOTIVE.

A CORRESPONDENT from South America asks the following question :

> What is the best and simplest method of calculating the horse-power of a locomotive—that is to say, to find some fixed power for any given locomotive? Naturally an engine will vary in its effective power according to conditions—going down a grade, up a grade, or on the level. To calculate the horse-power of any stationary engine I fully understand, but have long been puzzled to find out means to obtain the horse-power of a locomotive. Perhaps the term horse-power is misapplied in connection with a locomotive, and that all that is required is *capacity* to haul so many tons.

The inquiry of our correspondent is one which is often made, and is generally left unanswered, or the querist is silenced by the remark that "We don't count the power or capacity of a locomotive by horse-powers." There is no reason, however, why it should not be possible to calculate the horse-power of locomotive engines as well as that of stationary or marine engines. It is of course true, as our correspondent remarks, that "a locomotive engine will vary in its effective power according to conditions—going down a grade, up a grade, or on a level." In other words, a locomotive has a maximum horse-power at different speeds, and it may develop any horse-power *less* than its maximum at any speed. The most important aspect of the question, then, will be to ascertain the *maximum* horse-power which a locomotive will develop at different speeds. It may also be said here, that what follows will have no reference to that old myth called a "nominal horse-power" established about a century or more ago by the practice of Boulton & Watt. Only actual or indicated horse-power will be considered.

There are two sources from which we may obtain the requisite data to calculate the actual horse-power of a locomotive : one is the effective pressure in the cylinders, which is shown by an indicator ; the other is the work done by the locomotive—that is, overcoming the resistance of the train hauled. Thus, suppose that an engine which, with its tender, weighs 75 tons (of 2,000 lbs.), and has 60,000 lbs. adhesive weight on its driving-wheels, pulls a train of cars weighing 1,500 tons on a level and straight track at a speed of 10 miles per hour. The resistance of such a train in good condition would be about 5 lbs. per ton, and we would have total weight of cars, engine and tender of 1,575 tons $\times$ 5 = 7,875 lbs. Allowing $7\frac{1}{2}$ lbs. per ton on the weight of engine and tender for the friction and resistance of the machinery, and we have $75 \times 7\frac{1}{2} = 562.5$ and 7,875 lbs. + 562.5 = 8,437.5 = total resistance of train. At 10 miles an hour the train is moving at a speed of 880 ft. per minute ; $880 \times 8{,}437.5 = 7{,}425{,}000$ = number of foot-pounds of work exerted by the engine per minute. As is well known, a horse-power is equivalent to raising 33,000 lbs. one foot high, or exerting that many foot-pounds per minute ; therefore $7{,}425{,}000 \div 33{,}000 = 225$ = the horse-power of the engine working under these conditions. Now we may calculate, in a similar way, the resistance of any train which a locomotive has hauled or may haul at a known speed, and from this deduce the horse-power exerted. To do this a very convenient table of train resistances at different speeds and on different grades will be found in *The Catechism of the Locomotive.* It should be added that our knowledge of this subject is not very exact, and probably the resistances given in that table are too high. It will be safe to deduct 1.5 lbs. in all cases from the resistances given in the table if the rolling stock is in good condition. The same remark will apply to our knowledge of the internal resistance of the machinery of a locomotive. The rule given by Molesworth for the friction of engines may be used—that is, divide 18 by the square root of the diameter of the cylinders in inches ; the quotient will be the steam pressure in pounds per square inch required to overcome the internal friction of the machinery. This known, the tractive force which that pressure would exert may be calculated by any of the rules for that purpose. From such data the horse-power which a locomotive actually exerts may be calculated for any conditions of working.

In Clark's *Railway Machinery* the following rule is given : "*For the Horse-power of a Locomotive.*—Multiply the speed in miles per hour by the square of the diameter of the piston in inches—by the stroke in inches—and by the effective mean pressure on the piston in pounds per inch ; divide the product by the diameter of the driving-wheels in feet, and by 4,500. The final product will be the horse-power."

Another rule would be, multiply twice the area of one of the pistons (for simple engines) by the effective mean steam pressure in the cylinders—the product by the average piston speed in feet per minute, and divide by 33,000. The quotient will be the horse-power.

Now, in both these rules the difficulty will be to ascertain the effective mean steam pressure in the cylinders. Of course if indicator diagrams have been taken, and it is desired to know what horse-power was developed at the time the diagrams were taken, the latter will give the effective

average steam pressure ; but as we understand our correspondent's inquiry, he wants some rule by which he can calculate the horse-power of any locomotive of which he knows nothing but its dimensions and the boiler pressure. The missing link in such cases is the average effective steam pressure in the cylinders. In starting and at very slow speeds it is, of course, possible to get an average pressure in the cylinders very nearly as great as that in the boiler, but a little calculation and less practical expense will show that at high speeds—say 60 miles an hour—no locomotive can have an average pressure in the cylinders anywhere near to that in the boiler. Even if it was practicable at that speed to get enough steam of that pressure into the cylinders to fill them and get it out again at the end of the stroke, no boiler now in use could supply enough of it. Locomotive driving-wheels 5 ft. in diameter, at 60 miles an hour, would make over 20,000 revolutions per hour. If the cylinders are 18 × 24 in. they would consume more than 100,000 lbs. of steam of 150 lbs. pressure if they were filled with it and it was exhausted at each stroke of the pistons. If the grate had 25 sq. ft. of area and burned 150 lbs. of coal per foot per hour, and evaporated 6 lbs. of water per pound of coal, it would produce only 22,500 lbs. of steam per hour. Besides this, it would, as already remarked, be impossible to get that quantity of steam into and out of the cylinders at that speed, and if it was possible to do so, the violence of the exhaust would tear the fire to pieces and carry most of the coal up the chimney. For these and for other reasons the effective mean pressure on the piston in practice is diminished as the piston speed increases. Now at what rate is it reduced ? If we can establish some rule of practice, we will have the missing link by which we may be able to calculate the horse-power of any locomotive of which we know the size of its wheels and cylinders and the steam pressure in the boiler, providing, of course, that the boiler and other parts are properly proportioned.

We are indebted to Mr. Reuben Wells, of the Rogers Locomotive Works, for the results of an investigation of this kind. He examined all the indicator diagrams, showing the performance of locomotives which he considered reliable. The results of this investigation are embodied in the table, given in the next column :

Diameter of driving-wheels in inches.	Approximate train speed per hour due to the diameter of drivers.	Piston speed in feet per minute (approximate).	Per cent. of boiler pressure effective on the pistons for the whole length of the stroke.
50 to 54 inches.	6 miles.	160 feet.	88 per cent.
50 " 54 "	10 "	200 "	85 " "
54 " 56 "	15 "	400 "	75 " "
54 " 56 "	20 "	500 "	68 " "
60 " 62 "	26 "	600 "	60 " "
60 " 62 "	33 "	700 "	52 " "
66 " 68 "	40 "	800 "	44 " "
68 " 72 "	45 "	900 "	36 " "
78 inches.	53 "	1,000 "	33 " "
78 "	60 "	1,100 "	31 " "
78 "	65 "	1,200 "	30 " "
78 "	70 "	1,300 "	28 " "
78 "	75 "	1,400 "	27 " "

Implicit reliance cannot of course be placed on these figures. It is only an attempt to work out the problem from the data which are now accessible. In order to show the results graphically, the data contained in the third and fourth column of the table have been plotted in the accompanying diagram. On the base-line *A B* vertical lines or ordinates are drawn, the spaces between indicating average piston speed in feet per minute, each space representing 100 ft. The figures below the base-line indicate the piston speeds represented by each vertical line. From the base-line, at points representing the piston speeds indicated in the third line of the table, there have been laid off to scale vertical distances representing the percentage of boiler pressure effective on the pistons, as given in the fourth column of the table. The points thus laid down are indicated by crosses. A curve has then been drawn through these points as nearly as practicable. The vertical distance of this curve from the base-line at any point should therefore represent the effective boiler pressure in the cylinders for a piston speed indicated by the point on the base-line from which the measurement is made. The figures on the vertical lines indicate the vertical distances of the curve from the base-line measured on these ordinates. These figures, it will be seen, differ slightly from those in the fourth column of the table, as might be expected. The question arises how nearly the curve represents actual practice, or the average effective pressure in the cylinders of locomotives when they are working at their maximum capacity at different piston speeds. If the curve does represent the average effective pressures in the cylinders correctly, then all we need do to calculate the horse-power of a locomotive is to take the required average pressure from the diagram and use it with either of the rules given above.

It is a very inviting field for investigation. If some one having the requisite facilities for doing so would take a series of indicator diagrams, which a well-designed and constructed locomotive would produce when doing the maximum work of which it is capable when working with different rates of piston speed, it would be a very valuable contribution to our knowledge of the subject. It is by work of this kind that unknown men establish reputations, which should be an inducement to some one to undertake it.

Owing to the fact that indicator diagrams are not always, and in fact seldom are, taken when locomotives are doing the maximum work of which they are capable at the speed at which they are indicated, it seems probable that Mr. Wells's figures of average effective pressures may be too low, and it also appears likely that the curve of pressures may assume the form of a straight line, as indicated by the dotted line in the diagram. If this should prove to be the case, then, determining the average pressure for any piston speed would become a very simple matter, and if the average effective pressure at a piston speed of 1,500 ft. per minute was 25 per cent. of the boiler pressure, as indicated in the diagram, then the pressures for the intervening speeds would be as shown by the figures above the dotted line.

Who will undertake the making of such a series of indicator diagrams as have been suggested ?

NEW PUBLICATIONS.

CAB AND CABOOSE: THE STORY OF A RAILROAD BOY. By Kirk Munroe. New York ; G. P. Putnam's Sons. Illustrated. 264 pages ; price, $1.25.

Mr. Munroe has a talent for writing boys' stories which is not very common among authors, for there are many who can write for men where there is one who can suit boys. His stories are usually bright, lively and full enough of incident to be interesting, without descending to the level of sensationalism. In the present book he has told the story of a boy who left home to take up the life of a trainman. Of course his hero is successful, and of course he meets with many adventures which do not often fall to the lot of the occupants of a caboose ; but the action is not more overdone than we have to expect in a story, and the Author does not conceal the fact that hard work and hard knocks are a large part of life with the brakeman, as indeed they are with most of us. The hero of *Cab and Caboose* succeeds because he is a bright boy, and if chance throws opportunities in his way that come to a very few in ordinary life, we cannot blame the story-teller. The book is a good one for boys, who may learn some worthy lessons from its pages ; and the pictures of railroad life are fairly truthful ones.

ENGINEERS' SURVEYING INSTRUMENTS ; THEIR CONSTRUCTION, ADJUSTMENT AND USE. By Professor Ira O. Baker, C.E. *Second Edition, Revised and Enlarged.* New York ; John Wiley & Sons. Illustrated, 391 pages ; price, $3.

The first edition of Professor Baker's book has found general acceptance as a convenient text and reference book, and the present edition should be still more acceptable. Originally prepared for the use of his students in the University of Illinois and used in manuscript form for several years, the author was able to improve it by consideration of the questions brought up in the classes from time to time, thus adapting it to the requirements of students.

It is not intended to be a treatise on surveying, but simply, as the title indicates, to acquaint the student with the construction of instruments and the best methods of adjusting and using them. Some instruction on methods of surveying has necessarily been included, but this has been avoided as far as possible. It has been found that the practical instruction given to students in a college course needs to be supplemented in order to make them sufficiently familiar with the instruments they have to use.

An appendix gives a number of problems, with methods of solution. The value of the book is increased by a very complete index, and the whole arrangement of its contents is very convenient. The student will find it a valuable work, and the engineer a very useful addition to his library.

ORIGINAL PAPERS ON DYNAMO MACHINERY AND ALLIED SUBJECTS. By Dr. John Hopkinson. New York ; the W. J. Johnston Company, Limited. Illustrated, 240 pages ; price, $1.

The value of Dr. Hopkinson's studies and investigations on electrical subjects and of his resulting discoveries is well known ; but the papers which he has had time to publish have existed heretofore only in a scattered form, as they were first issued in various publications. In this volume they have been collected, by his authority, making them much more useful and accessible to electricians.

Nearly every one of these papers has been the result of some new discovery or marked advance in electrical knowledge. The first three papers are devoted to the Characteristic Curve, which has been so great an aid in studying and designing dynamos.

The fourth and fifth papers are on the theory and design of continuous current dynamos, and furnished the fundamental principles of the design of such dynamos.

The sixth paper established most important principles in relation to coupling alternate current machines. The seventh, eighth and ninth are on Transformers ; the tenth on the Theory of the Alternate Current Dynamo ; and the last on Electric Lighthouses.

Most of these papers were originally published in the transactions of different societies. With two or three exceptions they contain no mathematical formulas, and most of them can be read and the reasoning followed without any special knowledge of mathematics.

The illustrations, chiefly diagrams, are sufficient, though some of them have been reduced to rather too small a scale.

It may be added that the book includes all the original papers Dr. Hopkinson has published ; and some of them are now made generally accessible for the first time.

NOTES ON THE YEAR'S NAVAL PROGRESS. *Annual of the Office of Naval Intelligence. Compiled for the Use of Naval Officers and Others.* Compiled by the Office of Naval Intelligence, Navy Department. Washington ; Government Printing Office.

This volume is the eleventh in the series issued yearly by the Naval Intelligence Office, and while it follows the general lines of the previous ones, there has been some change in the methods of treating the different topics.

The general headings are : I. Notes on Ships and Torpedo Boats. II. Notes on Machinery. III. Notes on Ordnance. IV. Notes on Naval Administration and *Personnel.* V. Notes on Electricity. VI. Naval Manœuvres of 1891. VII. Armor in 1892. VIII. Some Standard Books on Professional Subjects.

The notes on Ships and Torpedo Boats, on Machinery and on Ordnance form the principal features of the volume. Chapter IV, Notes on Administration and *Personnel*, forms a new heading, although it is a continuation of articles which have appeared in previous numbers. Chapter V, on Electricity, is in the form of notes on progress made since the appearance of the last volume.

Especial interest attaches to Chapter VII, on Armor, which gives a summary of the very important tests made during the year. This chapter is accompanied by numerous illustrations showing the condition of plates after the tests.

The Notes on Ordnance include some very interesting accounts of recent developments in rapid-fire and machine guns. This chapter also is well illustrated, and, it may be added, does not neglect the subjects of small arms and torpedoes.

The notes on Machinery include accounts of the progress made on new engines for our own Navy, and comparative accounts of the results derived from a number of speed trials.

The vibrations of marine engines and experiments in the use of liquid fuel are also included in the subjects touched on.

The chapter on Naval Manœuvres gives critical accounts of the evolutions of the English, French, German, Austrian and Russian fleets during their customary summer exercises. While these are chiefly valuable to naval officers, they are not without their interest to non-technical readers, as showing the way in which modern ships may be fought in case of actual war.

It may be said that the present volume shows that the Naval Intelligence Office intends to fully maintain the standard set in its previous publications, and to establish its claims to usefulness.

ELECTRICITY AND MAGNETISM: *Being a Series of Advanced Primers.* By Professor E. J. Houston. New York; the W. J. Johnston Company, Limited. Illustrated, 306 pages; price, $1.

A set of Electrical Primers was issued by Professor Houston in 1884 for the benefit of those who desire to acquire some knowledge of the fundamental principles of electricity. The present series is a new one, written in view of the great advances made in electrical science during the past eight years, and also of the fact that the many commercial applications of electricity have made the public generally acquainted with at least the first principles, and that more advanced instruction was asked for. The book, however, can readily be understood by those who have no previous knowledge of the subject.

The book may be divided into three heads: the first, Electricity and Magnetism; the second, Electric Currents and their Measurement; the third, the Electric Telegraph and other applications. The concluding section is a general review. The subjects of the sources of electricity, atmospheric electricity, the earth's magnetism, the electro-magnet, and induction are treated in an interesting way.

To each chapter there are appended abstracts from and references to standard electrical books, a very useful feature for readers who would like to extend their studies.

Although intended for popular reading, the book is not without its uses for electricians.

TIPS TO INVENTORS. *Telling what Inventions are Needed and How to Perfect and Develop New Ideas in any Lines.* By Robert Grimshaw, Ph.D., M.E. New York: the Practical Publishing Company; price, $1.

This is a kind of book which is difficult to criticise. It is a collection of hints as to inventions for which there appears to be a demand; as to methods by which they can be worked out and the routine to be followed in securing a patent. It can hardly be said to follow any definite plan, although it is classified into chapters on different subjects. Of course there is much in it not especially new, but it contains some good suggestions, and the reader may find in it hints that may be of value to him.

CURRENT READING.

THE writers in the NORTH AMERICAN REVIEW for December cover a wide range of topics, and some notable names are included among them. Mr. Balfour discusses the Irish Question from a Tory standpoint; Colonel Dodge writes of the Horse in America; Lord Dunraven of International Yachting; M. Naquet of Divorce; Minister Grubb of Ballot Reform; and Dr. H. G. Williams has a warning if somewhat gloomy article on General Paresis of the Insane. The Governor of Jamaica tells of the Opportunities for Young Men in that island; and there are the usual notes and comments on current events.

The oldest of all the magazines now in existence has recently experienced a revival. GODEY'S MAGAZINE, which for many years had been published in Philadelphia in the same form which was given to it fifty years ago, has passed into new hands, and appears in a shape which indicates the publisher's purpose to bring it to a front rank among its contemporaries. While still devoting a part of its space to the ladies who have heretofore been its chief supporters, it has entered the field of the general literary magazines with a vigor which promises well for the future. The December number, being the special holiday number, is chiefly devoted to fiction, containing a complete novel and several shorter stories. It is very handsomely illustrated, and has several fine colored plates which will be especially interesting to its lady readers.

An article by Professor Heilprin on Summer Travel in the Arctic Regions; one by W. H. Russell on the Fall of Sebastopol and one by C. F. Lummis on an incident in the romantic history of the Southwest, are among the attractions of SCRIBNER'S MAGAZINE for January. Stories, sketches and other lighter matter complete the number.

Some very attractive illustrated articles appear in the January number of HARPER'S MAGAZINE. Among these Julian Ralph's account of The Old Way to Dixie, and Theodore Child's description of life and scenes in Proletarian Paris, will enlist the attention of every intelligent reader. Other articles which will forcefully appeal to the tastes of a cultivated audience are a paper of personal reminiscences of Tennyson, by Annie Fields, and a comprehensive article on Pensions by Edward F. Waite. The number is also particularly rich in fiction, including the opening chapters of two important serials. The editorial departments contain a variety of inviting features.

The December number of the ARENA, which begins a new volume, has some valuable articles presenting different opinions on such questions as Government Ownership of Rail roads; Compulsory Arbitration; the Opening of the World's Fair on Sundays; Socialism; and others of almost equal moment. This magazine has done much toward drawing out the best thought on current topics by opening its columns to free discussion and presenting all phases of opinion; and readers who are interested in such discussion owe much to the editor, Mr. B. O. Flower, who had the enterprise to start the magazine and the courage to present the arguments contributed. In no other periodical can the reader find so much food for serious thought and such entire freedom from prejudice and custom.

In OUTING for December Lieutenant Bowen concludes the history of the National Guard of New Jersey. There are sketches of hunting and travel in the Platte Valley, in Manitoba, on the Paraguay, in Ceylon and in the almost unknown region along the border between Canada and the United States west of Lake Superior. An article on Athletics in Japan is illustrated by some very striking reproductions of drawings by Japanese artists. It is a very good number on the whole, and quite worthy of the special holiday cover which ornaments it. The January number is a special holiday number, and is marked by some illustrations of a very high class, and a number of excellent articles.

In the number of HARPER'S WEEKLY for December 7 there is a well-illustrated description of the Military Academy at West Point, showing the improvements made in recent years and also those now in progress. There is also an article on the Panama Canal Crisis in France.

Probably the best of the special magazines which comes to

our table is STONE, a monthly issued in Indianapolis by the D. H. Ranck Publishing Company, and devoted, as its name indicates, to the stone quarrying and building interests. It has 96 pages about the size of *Harper's*, is handsomely printed and well illustrated, and contains much information valuable to its special constituency, while quite a number of its articles have interest for the general reader. The November number has articles on the Marble Region of East Tennessee; the Sandstone Interests of Northern Ohio; the Areal Work of the Geological Survey; Drawing for Workmen; Durability of New York Building Stones; Whetstones in the United States; and a number of short articles, including Notes from the Quarries, Building Items and similar matters.

In the OVERLAND MONTHLY for December the paper on the University of California is concluded, the present number containing some excellent illustrations. The centennial of Vancouver's visit to the Bay of San Francisco in 1792 is the occasion of an interesting paper. Other articles include the Restaurant of San Francisco; a Mexican Ferry; Congressional Reform; and several stories and sketches.

A paper in the POPULAR SCIENCE MONTHLY for January gives an account of the independent invention of the lightning rod by a Bohemian named Divis, a contemporary of Benjamin Franklin. Other leading articles are on Genius and Suicide; on Vegetable Malformations, and on Marriage and Kinship among the Ancient Israelites. There are also several shorter articles of interest.

The December number of the ECLECTIC MAGAZINE gives articles on Cholera, from the *Nineteenth Century;* Columbus, from the *National Review;* China, from the *Cornhill Magazine;* the Recent Heat-Wave, from the *Contemporary Review;* Over Education, from the *Saturday Review;* Our Molten Globe, from the *Fortnightly Review;* and a variety of shorter articles, making altogether an excellent specimen number of current English literature.

The November number of GOOD ROADS has several effective articles, including some illustrations of roads as they are and as they ought to be. That on Street Improvements in Dunkirk shows what can be effected by well-directed work in a small town.

The December number of the ENGINEERING MAGAZINE has articles on Reciprocity with Canada; Architecture in Wood; Building the Cable Railroad in New York; Industrial Development in the South; Our Remaining Hardwood Resources; Irrigation Problems in the West; Labor Troubles and the Tariff; Gold Fields of Bendigo, Australia; the World's Fair and the Death-Rate; Are American Mechanics Boastful? and the usual special departments.

In the JOURNAL of the American Society of Naval Engineers for November Chief Engineer Isherwood gives an analysis of the results of the experiments recently made on the side wheel steamer *Ville de Douvres*, which have attracted much attention abroad. There are papers on Speed Trials, by Naval Constructor Taylor; Propeller Efficiency, by Professor W. F. Durand; and some excellent lectures delivered at the Naval War College by Passed Assistant Engineer Hollis on the Coal Endurance and Machinery of the New Cruisers. There are also several shorter papers and a number of notes on points connected with naval work.

The articles in GOLDTHWAITE'S GEOGRAPHICAL MAGAZINE for November include a continuation of that on Columbus, and papers on Stream Corrosion; the Prehistoric Races of Italy; Modern Palestine; the Chinaman in America; the Florida Gulf Coast; the Temperature of the Circumpolar Regions; the 84th Eruption of Mt. Etna; and several shorter articles.

BOOKS RECEIVED.

Twenty-third Annual Report of the State Board of Health of Massachusetts. Henry P. Walcott, M.D., Chairman of Board; Samuel W. Abbott, M.D., Secretary; F. P. Stearns, C.E., Engineer. Boston: State Printers.

Results of Tests of Crucible, Basic and Galvanized Basic Steel Wire Ropes and Basic Steel Wire Rods. Bulletin No. 11 of the Department of Mechanical Engineering, University of California. San Francisco; published for the University.

River Pollution and River Purification. By H. Alfred Roechling, C E. This is a reprint of a paper read recently before the Association of Municipal & County Engineers, at the annual meeting in Bury, England.

Selected Papers of the Institution of Civil Engineers. London, England; published by the Institution. The present installment includes the annual address of the President, Mr. Hayter; papers by Mr. Donkin on Measurement of the Velocity of Air in Pipes; Mr. Preller on the Zurich Water Power and Electric Light Works; and Mr. Szlumper on the Waterloo New Signal Station.

The Inclined Plane for the Transfer of Canal Boats at Beauval, near Meaux. By M. A. Mallet. Paris. This is a reprint of a paper read by M. Mallet before the French Society of Civil Engineers.

John Stevens and His Sons: Early American Engineers. By J. Elfreth Watkins. Washington; published for the Author. This is a reprint of a very interesting paper read by Mr. Watkins before the Philosophical Society of Washington.

Annual Report of the Postmaster-General of the United States for the Fiscal Year Ending June 20, 1892: Hon. John Wanamaker, Postmaster-General. Washington; Government Printing Office.

TRADE CATALOGUES.

How to Use Portland Cement. The Buckeye Portland Cement Company, Bellefontaine, O.

This little pamphlet contains notes on various uses to which Portland cement can be put; and incidentally, some advertising of the Buckeye Company's cement, the good qualities of which are well known.

Hydraulic and Rolling Mill Machinery. H. V. Loss, Hydraulic Engineer, Philadelphia.

This pamphlet describes several hydraulic machines devised by Mr. Loss, including riveting and forging machines; shears and punches; high-pressure pumping engines; accumulators for hydraulic presses; valves, packing and other fitting.

Steel Castings. The Pittsburgh Steel Casting Company, Pittsburgh, Pa.

This pamphlet contains some interesting information about steel castings in general, and some statements as to the work done by this company. Some of its specialties are hammer heads and dies, cams, rolls, gearing of all sorts, and wheels, although all classes of castings are made in its works. Reports of recent tests show excellent results, which can only be obtained by the use of the best material and most approved processes.

The Columbia Daily Calendar. The Pope Manufacturing Company, Boston, New York and Chicago.

This is a very handy pad calendar, consisting of 366 leaves, one for every day in the year, and a calendar for the entire

year. The day of the week, of the month, and of the year are given, and on each leaf is a short sermon on the Gospel of Outdoors, Health and Happiness, with valuable hints on practical road-making. The leaves are so arranged that there will be no stub left, and each one can be referred to at any time during the year. The pad is upon a metallic stand of ivory black, arranged so as to rest upon the desk at a convenient angle.

Catalogue of the Consolidated Car-Heating Company, Albany, N. Y. Part IV. Multiple Circuit System. Illustrated.

The Consolidated Car-Heating Company has adopted the novel plan of sending out its new catalogue in parts, so arranged that as each additional part is received it can be bound up with the earlier ones, a simple binding arrangement being provided. The present part contains an illustrated description of the company's multiple circuit system of car heating, a new arrangement for heating by hot water. When complete this catalogue will form quite an encyclopædia of continuous heating. It is handsomely printed and well illustrated.

AMERICAN AND ENGLISH LOCOMOTIVES.

The double-page engraving with this number is the first of a series of illustrations of two passenger locomotives, one of them designed by Mr. William Buchanan, Superintendent of Motive Power and Rolling Stock of the New York Central & Hudson River Railroad, and built by the Schenectady Locomotive Works. This engine, No. 903, is now running on the New York Central Line, and is one of the engines employed to haul the celebrated Empire Express. The other one was designed by Mr. W. Adams, Locomotive Engineer of the London & Southwestern Railway of England, and built at the Nine Elms Works of that company. These two engines are fair representatives of recent locomotive practice in the two countries. In succeeding numbers of this Journal it is intended, as already announced, to give a series of engravings, which will be published on opposite pages, showing the design and construction of all the principal parts or organs of these two machines, with descriptive and critical articles comparing the methods of construction of the two, and showing the relative advantages and disadvantages of each. In this introduction but little seems to be demanded, excepting to give the general dimensions, weight, etc., of the two locomotives, reserving the summing up until after the details have been fully illustrated and described.

From the table and the engravings it will be seen that the size of the driving-wheels of the two engines is within half an inch of being the same. The cylinders are of equal diameter, but the pistons of the English locomotive have two inches more stroke than those of its American competitor. Mr. Buchanan's engine, however, is 13,968 lbs. heavier than Mr. Adams's, and the former has 13,328 lbs. of its excess of weight on the driving-wheels. The New York Central machine, therefore, has 66.83 per cent. of its weight on the driving-wheels and the London & Southwestern engine has 62.26.

The rule which has been given for ascertaining what has been called the *modulus of propulsion*, or the measure of the capacity of the cylinders in proportion to the size of and weight on the driving-wheels, is:

"Multiply the area of one piston (in square inches) by the stroke (in inches) and the product by four. Divide this product by the circumference of the driving-wheels (in inches) and by the weight (in tons of 2,000 lbs.) on all the driving-wheels. The quotient will be the modulus of propulsion."

By applying this rule to both engines, we find that Mr. Adams's engine has a modulus of 3.28, whereas Mr. Buchanan's has only 2.49. It is true that the latter has a boiler pressure 5 lbs. greater than the former, which partly compensates for his smaller cylinder capacity. If we multiply the moduli by the boiler pressures it will give us quantities which represent correctly the relative capacity of cylinders, taking all the elements into account. These will be 590.4 for the English and 460.65 for the American engine. It will be seen from these figures that Mr. Adams's

General Dimensions, Weights, etc., of Locomotive No. 903, of the New York Central & Hudson River Railroad, and Locomotive No. 577 of the London & Southwestern Railway.

	American Engine.	English Engine.
Diameter of driving-wheels	84½ in.	85 in.
" " engine, truck and tender wheels	36 in.	45¾ in.
" " cylinders	19 in.	19 in.
Stroke of pistons	24 in.	26 in.
Lap of valve	1 in.	1 in.
Maximum travel of valve	5½ in.	... ...
Length of connecting-rod, center to center	8 ft. 1 in.	6 ft. 8 in.
Proportion of length of connecting-rod to stroke	1 to 4.04	1 to 3.07
Smallest outside diameter of boiler	58 in.	52 in.
Number of tubes	268	240
Length " "	12 ft.	11 ft. 4 in.
Diameter of tubes	2 in.	1¾ in,
Area of grate	27.3 sq. ft.	18 sq. ft.
Total heating surface	1821.5 sq. ft.	1,367.76 s. ft.
Height from top of rails to center of boiler	8 ft. 10¾ in.	7 ft. 9 in.
Boiler pressure	180 lbs.	175 lbs.
Total weight of engine and tender	203,500 lbs.	180,712 lbs.
" " " "	123,000 lbs.	109,032 lbs.
" " on driving-wheels	82,200 lbs.	67,872 lbs.
" " of tender, loaded	80,500 lbs.	71,680 lbs.
" length of engine and tender, over all	56 ft. 7¾ in	53 ft. 8⅝ in.
" wheel-base " " " "	46 ft 8½ in.	45 ft. 8½ in.
" " " "	23 ft. 11 in	23 ft.
Driving wheel-base	8 ft. 6 in.	8 ft. 6 in.
Weight of engine and tender per foot run of total length	3,595 lbs.	3,364 lbs.
Weight of engine per foot run of total length	3,471 lbs.	3,404.8 lbs.
" " tender " " " " " "	3,795 lbs.	3,360 lbs.
Water capacity of tank	3,587 galls.	3,300 galls.
Coal " " "	14,500 lbs.	......

engine has, relatively to its weight, considerably more cylinder capacity than the American competitor. On the other hand, the grate and heating surface in the latter is considerably greater than in the English machine, which is a consequence or result accruing from the excess of weight. These features will be discussed more fully in future. In the mean while, many of our readers will be interested in comparing the designs of the two machines.

SOME CURRENT NOTES.

As an example of the useful work which a technical school may undertake, Professor W. F. M. Goss, of Purdue University, at Lafayette, Ind., offers, through *Stone*, to make a full series of tests of Indiana building stones. The only conditions are that samples of the stone shall be forwarded to the Testing Laboratory of the University in 2-in. cubes ready for testing and properly marked and authenticated. The results of the tests will be a matter of record at the Laboratory, but will not be published except at the request of the owners of the specimens.

Ships, like men, sometimes come down in the world very much in their old age. Just before the War the *Santiago de Cuba* was the crack ship of the line between New York and Havana; during the War she was a naval cruiser and was considered one of the finest and fastest vessels in the blockading squadron, capturing as many prizes as any ship in the Navy. After the War she was sold, with many others, and after a varied service her hull, stripped of its cabins and other upper works, is now doing duty as a coal barge. The beam engine is still at work, however, having been put into the large excursion steamboat *Columbia* some years ago.

A French authority estimates the quantity of coal mined throughout the world in 1891 at 485,000,000 tons, the output from different countries being as follows: Great Britain, 182,000,000; United States, 141,000,000; Germany, 90,000,000; France, 28,000,000; Belgium, 20,000,000; Austria-Hungary, 9,000,000; Russia, 6,000,000; other countries, 9,000,000 tons.

The production for 1892 has probably been over 500,000,000 tons. At the present rate of increase the deposits of some of the leading coal-producing countries must soon be at least partially worked out. Within a few years Great Britain and Belgium will probably show a decrease; in a few years more the United States will become a coal-exporting country, while further in the future North China and Eastern Siberia will begin to contribute to the world's supply from the great coal deposits which are believed to exist in them.

WORK has been begun on the reclamation of the Zuyder Zee in Holland. This will require the construction of a dam from Ewijeksluis, in North Holland, to the island of Wieringen and thence to Makkum, in Friesland. The dam will be 18 miles long, and will be built through water from 13 to 20 ft. in depth; it will be carried to a height of 16½ ft. above low water, and its slopes will be protected by mattresses and riprap. There will be 24 flood-gates, each with an opening of 41 ft. Near the center of the present water area enclosed a lake will be left, which will be called the Yssel Meer, and this will be connected with the sea at Harlingen, in Friesland, by a canal 1,640 ft. wide and 14½ ft. deep. This lake will also be connected with Amsterdam by a canal. The estimated cost of the work is $95,000,000, which will be more than repaid by the value of the land reclaimed, nearly 1,000,000 acres.

THE work of draining Lake Angeline, in the Lake Superior iron region, has been completed. This lake was three-quarters of a mile long, one-third of a mile wide and 45 ft. deep at the center, and the work was undertaken by the mining companies whose properties adjoined it, and who wished to extend their workings under the bed of the lake. The outlet was closed and the water has been pumped into Carp River by large centrifugal pumps.

IT is now stated that the Hamburg-American Packet Company has closed a contract with the Vulcan Ship-building Company, at Stettin, Germany, for a twin-screw steamer to be 600 ft. long and to have a guaranteed speed of 22 knots an hour. The ship will be about the same size as the new Cunard Line steamers, and is to be finished in two years.

THE University of Chicago is to have the largest telescope in the world, which will be named the Yerkes Telescope, after the giver. It will have a 40-in. objective, that of the Lick Observatory telescope, in California, being 36 in., and that of the new Naval Observatory telescope, in Washington, 26 in. The tube of the new telescope will be 75 ft. long, and will weigh about 12,000 lbs. It is to be built by Warner & Swasey, of Cleveland, O., the builders of the Lick instrument.

THE export of steel from the United States to England has not been considered an ordinary operation; but it seems that steel and also files are now being sold in that country by American makers. A recent number of the London *Engineer* gives the following note from its Sheffield correspondent: "A Sheffield commission agent called upon me this week with specimens of American-made files, of which he had been asked to undertake the sale in this country. The United States people offer their files on terms which cut out local makes—viz., 70 per cent. discount and 5 off; in other words, for a nominal value of £100 they will take £28 10s. The files have been shown to file makers, and have been declared to be satisfactory in regard to quality. The United States firm, whose place of business is in New Jersey, state that they are sweeping the Canadian and Australian markets by running out the best brands of English files. To Canada, where the duties on English and American files are similar, they state that they are sending from $25,000 to $40,000 worth of goods a year, and are now opening up a connection in England itself, sending over from 200 to 300 dozen files per month. The American, of course, does not underrate himself or his productions; but it is certainly significant that he can place on the English market files which English managers declare to be excellent, at rates below local price lists. The files, it should be added, are machine-made in every instance. Another American steel house has stored in London several hundred tons of the best crucible steel, and have already engaged a Sheffield gentleman to represent them in this country."

THE Canadian Government engineers have completed borings and preliminary surveys for the proposed tunnel under Northumberland Straits, to connect Prince Edward Island with the main-land. The distance is eight miles, the greatest depth of water 96 ft., and the bottom is generally favorable for tunneling.

THE pollution of the Seine by the sewage of Paris has become recently so serious a matter that it is proposed to build a trunk or canal sewer the entire distance from Paris to the sea. At present the sewage is distributed to farms at points just below the city, but this arrangement has proved insufficient, and a large quantity passes into the river.

UNDER the direction of the Lighthouse Board some interesting experiments have lately been made at Long Beach to determine the relative visibility of white and colored lights. While there is some difficulty in securing uniform results, it was decided that a white light of one candle-power could be seen one mile distant; two candle-power, two miles, and 30 candle-power, five miles. Red and green lights required four candle-power to make them visible at one mile, and 40 candle-power for two miles. The great difference is due to the absorption of light by the colored glass.

IT is stated that arrangements are in progress for resuming work on the ship railroad across the Chignecto isthmus, in Nova Scotia, which is to carry vessels from the head of the Bay of Fundy to Northumberland Straits. A large part of the work has been completed, but work was stopped some time ago on account of lack of money.

SOME experiments are to be made at the lighthouse station at Tompkinsville, N. Y., with a flash-light of great power, invented by Professor Schirm, of Berlin. The flash is produced by a jet of magnesium powder ignited by a small benzine lamp. Air is passed through cylinders containing pumice stone saturated with benzine, and the gas is thrown out with a spray of magnesium powder against the lamp and thus ignited. The interval between the flashes is regulated by clock-work.

THE addition of small portions of citric acid, tartaric acid, or hydrochloric acid to water is said, by good medical authority, to be efficacious in destroying cholera germs. This can often be done where it would be difficult to boil the water.

A NEW storage battery electric car is now running experimentally on the Ninth Avenue surface line, in New York, which has very heavy grades. The car weighs 12,500 lbs., the batteries of 144 cells weighing about 3,900 lbs. They can operate the car for about six hours of continuous running without renewal.

SOME tests of the Baker submarine boat, which has been described and illustrated in our columns, are now being made in Lake Michigan, near Chicago. So far this vessel has been remarkably successful.

THE new steamers for the Inman Line between New York and Southampton have been begun. Two of them are to be larger than the *City of New York*, and will have engines capable of working up to 25,000 H.P.; four will be somewhat smaller, and will have engines of 17,000 H.P. All the ships will have twin screws and quadruple-expansion engines, working at 210 lbs. pressure.

THE New York, New Jersey & Eastern Railroad Company has recently filed maps and profiles for a double-track railroad tunnel to extend from the Long Island Railroad tracks in Brooklyn, under Atlantic Avenue and the East River to the lower part of New York, and thence under the Hudson River to a connection with the Pennsylvania Railroad in

Jersey City. The plans include stations at convenient points, to be connected with the tunnel by elevators. The project has before been referred to, and it is understood that it has the support of Austin Corbin and others connected with the Long Island Railroad. The tunnel will be about 3½ miles long, and its estimated cost is about $7,000,000.

THE report of General T. L. Casey, Chief of Engineers, for the year ending June 30 shows that there are now 117 officers holding commissions in the Corps of Engineers. Of these 20 are employed on various special duties; 20 on detached service; 14 are serving with the Engineer Battalion and the Engineer School; 30 are engaged on fortifications and river and harbor work, and the remaining 33 are exclusively employed on river and harbor improvement work.

FOR the first time in 15 years construction work on coast fortifications has been resumed, appropriations having been made in 1890 and 1891 for the building of new batteries at Boston, New York, Hampton Roads, Washington, and San Francisco.

THE report of the Board on Ordnance and Fortifications, which has just been submitted, makes some important recommendations. In brief the Board asks for:

1. Greater facilities and increased appropriations for testing and proving guns, mortars, etc.;

2. A Government gun and mortar carriage factory which can turn out mounts commensurate with the production of guns and mortars;

3. The early test and selection of an acceptable type of disappearing carriage for 8-in. and 10-in. guns;

4. Increased and immediate appropriations for the acquirement of sites and construction of additional gun and mortar batteries, and

5. A constant supply of forgings commensurate with the output of the army gun factory.

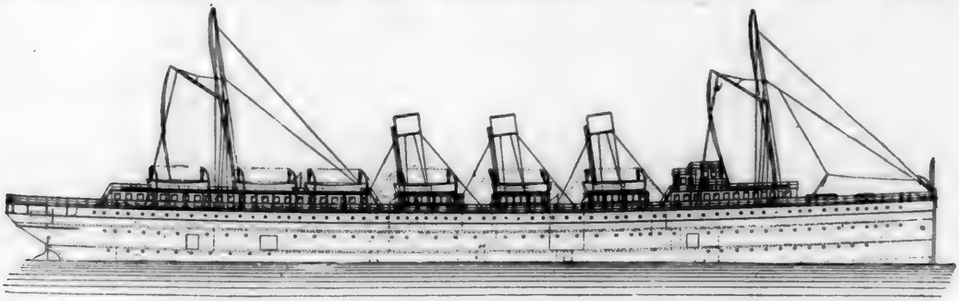
The Board submits an estimate of an appropriation of $270,207 to make purchases, experiments and tests to ascertain the most effective guns, small arms, ammunitions, armor-plates, etc. The Board recommends a repeal of the law pledging the United States to the purchase of 50 cast-iron mortars, 50 10-in. and 50 12-in. guns.

THE Sault Ste. Marie Canal closed for the season on December 7. The freight which passed through this year reached 11,241,000 tons, an increase of 2,325,000 tons over last year. Every important article of commerce shows an enormous increase—grain 61 per cent., flour 43 per cent., and iron ore 38 per cent.

IT is stated that recent improvements in the Sims-Edison torpedo have much increased its speed and the ease with which it can be steered. Some extraordinary results in passing under booms and other obstacles have been attained in recent experiments at the torpedo station at Willet's Point. A speed of 18 miles an hour has been given the torpedo, and at that rate it struck and then passed under a heavy spar and continued its course without damage.

ON December 1 there were, according to the *American Manufacturer's* tables, 255 furnaces in blast, having a total capacity of 175,921 tons of pig iron per week—an increase of 1.1 per cent. over the November statement. The comparison with December 1, 1891, however, shows a decrease of about 10 per cent. in the weekly output. It is still large, and the present tendency is toward a gradual increase.

THE Globe Iron Works, in Cleveland, have now on the stocks two steamers, the first of a line to run between Buffalo and Duluth for the Great Northern Railroad Company. They are 360 ft. keel, 380 ft. over all, 44 ft. beam and 34 ft. deep. They will have accommodations for 320 cabin and 300 steerage passengers. They will carry water ballast in a double bottom so that their draft of 18 ft. on the open lakes can be reduced when necessary to enter a harbor. As will be seen from the accompanying sketch—from the *Marine Review*—they will present the general appearance of an ocean steamer, rather than of the ordinary lake boat, the sides being carried up to the top of the cabins.



PASSENGER STEAMER FOR THE GREAT NORTHERN LINE ON THE LAKES.

Mechanically their peculiarities will be in the use of twin screws, each driven by a quadruple-expansion engine with cylinders 25 in., 36 in., 51¼ in. and 74 in. × 42 in., and in the use as steam generators of tubulous boilers of the Belleville type, working at 210 lbs. pressure. Each ship will have 28 of these boilers, and their arrangement has been designed by Mr. Miers Coryell, of New York. The engines are designed to develop 7,000 H.P., and to give the ship a speed of 20 miles an hour.

THE first locomotive built in Australia has just been completed by the works of David Munro & Company in Melbourne, for the Victorian Government Railroads. It is similar to a number in use on those lines, and is a tank engine having four coupled drivers 60½ in. in diameter under the boiler; a pair of 42-in. leading wheels at the forward end and a pair of 42-in. trailing wheels behind the fire-box. The cylinders are 17 × 26 in., placed inside the smoke-box. Water is carried in side tanks and in a tank placed on the frames behind the fire-box.

THE Argentine Republic has now 7,310 miles of railroad, besides 1,520 miles under construction. Of the completed mileage 4,523 miles are of 5 ft. 6 in. gauge; 634 miles of 4 ft. 8½ in.; and 2,153 miles of meter gauge. The average cost of all the lines is reported at about $50,000 per mile. Only 186 miles have a double track.

The State lines include 638 miles; the guaranteed lines—that is, lines built by companies whose securities are guaranteed by the Government—2,024 miles; and the unguaranteed lines owned by companies 4,648 miles. There are in use on these roads 699 locomotives and 1,192 passenger cars; the number of freight cars is not stated, but their total capacity is rated at 268,000 tons.

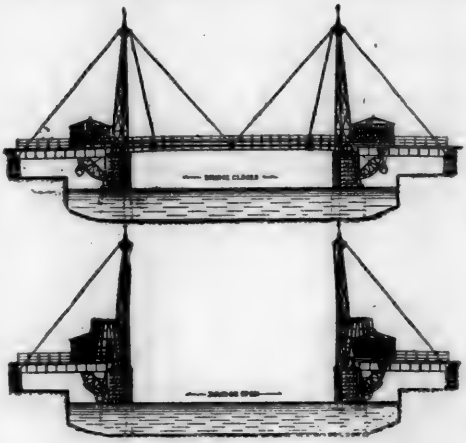
Business and political complications made last year a very unfavorable one for the Argentine lines, and their traffic and earnings show heavy decreases when compared with more prosperous years. Parallel lines and competition have

also begun to affect business, and the original faults of construction are becoming manifest.

STREET pavement of brick has been laid in Dunkirk, N. Y., at a cost varying from $1.60 to $2.37 per square yard, and experience has shown that it stands well under heavy traffic. Vitrified brick is to be used extensively in paving the streets of Toledo, O. There is no doubt that good brick presents many advantages for street paving.

THE steel rail mills are not very busy at present, the railroad companies having apparently held back their orders for the year as much as possible. There are few orders at present for rails for new construction, and while a large quantity will be needed for renewals, as usual, there is a delay in placing contracts.

A BRIDGE of the Harman pattern is now in use at the Weed Street crossing of the river in Chicago; it has a span of 60 ft., and another of 80 ft. span is to be built at the Canal Street crossing. As shown in the accompanying sketch, this is a double-jointed bascule or folding bridge, an outer joint permitting the end of the lifting leaf or panel to fold back. This requires a peculiar arrangement of the



HARMAN LIFTING BRIDGE, CHICAGO RIVER

counterweights. The advantages claimed for this form of bridge are that it requires less counterbalancing than an ordinary lifting bridge, is less likely to interfere with a ship's rigging, and offers less resistance to wind when open. On the other hand, it is somewhat more costly, and is necessarily less stiff than the ordinary lifting bridge of a single span.

ONE of the largest floating cranes in existence is now in use at the Cramp yards in Philadelphia; it is at present employed in placing the boilers, engines, and heavy armor-plates on the new cruiser *New York*. It is of the usual form of these cranes, a mast rising from a floating pontoon and steadied by a conical framework; this mast carries a horizontal arm or boom on which the traveler carrying the load works. The capacity of this crane is rated at 125 tons. The pontoon is of iron and is braced and divided into compartments by several bulkheads; it is 69 ft. long, 62 ft. wide, and 18 ft. deep. It is provided with capstans for moving itself when near a dock or other point where cables can be attached. When at work water can be let into some of the compartments to balance the weight of the load; pumps are provided to pump out this water rapidly.

The conical framework staying the mast is built up of steel plates and angles; it is 65 ft. high from the deck of the pontoon. The lower part is covered with a wooden framework forming a house in which are placed the four engines, of 40 H. P. each, which work the crane, and the boilers which supply the steam. The mast is of steel, is 3 ft. in diameter and is hollow; it extends 51 ft. above the framework, or 116 ft. above the deck of the pontoon. It rests in a socket on 42 steel balls, each 4 in. in diameter. Another set of ball bearings is placed at the top of the cone.

The lifting arm of the boom is 65 ft. long, and is stayed to the top of the mast by steel cables. The short arm is 50 ft. long, and from its outer end a steel stay, strongly braced, extends to the top of the mast; it is also anchored to the pontoon by heavy cables. The boom is of steel. The lifting arm has two sets of pulleys, one for heavy and one for light weights.

Separate drums and cables are provided for lifting, for moving the traveler backward and forward on the boom, and for swinging the boom around. The size of the crane and the length of the boom give it a considerable range of work.

THE American Steel Barge Company recently launched at West Superior, Wis., the whaleback steamer *Christopher Columbus*, which is to be fitted up as a passenger boat, to carry excursionists to Chicago next summer. The hull is of the ordinary whaleback type, and is 362 ft. long, 42 ft. beam, and 24 ft. deep. There are on this hull seven elliptical turrets which will serve to support a deck on which the main cabin and saloon will be built, and will also contain the communications between this cabin and the hold. The engines, boilers, crew accommodations, dining-room, kitchen and other offices are below, leaving the entire deck clear for passengers. The main cabin will be 225 × 30 ft., with a promenade all around it, and above this will be the texas or hurricane deck. The hull is divided into several compartments and can carry 750 tons of water ballast.

The *Christopher Columbus* will have a single propeller 14 ft. in diameter and 9 ft. pitch, driven by a triple-expansion engine with cylinders 26 in., 42 in., and 70 in. × 42 in. There are six steel Scotch type boilers 11 ft. in diameter and 12 ft. long, built for 160 lbs. working pressure.

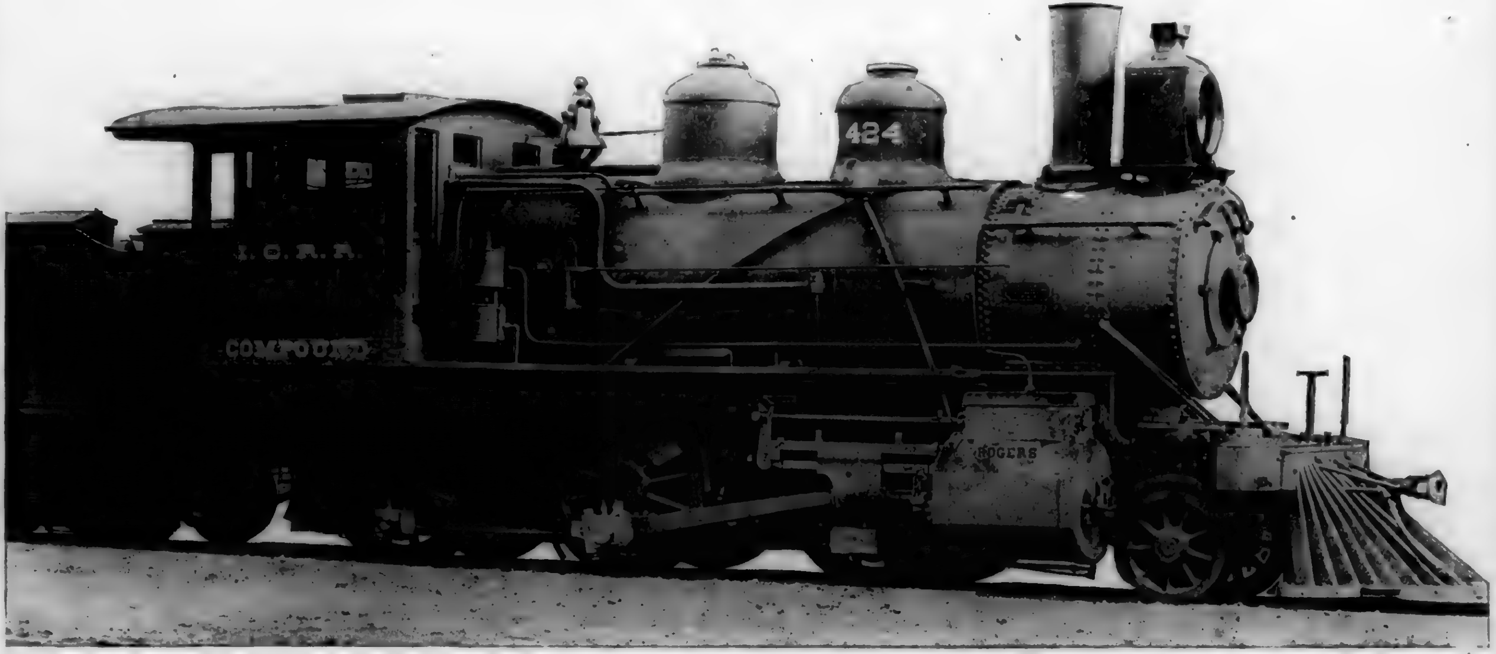
A NEW company has been organized and will ask the Connecticut Legislature for permission to build a dam across the Housatonic River near Oxford, Conn., where a fall of over 30 ft. can be obtained. The water-power will be used to operate dynamos and the power will be transmitted to the cities of New Haven and Bridgeport. It is believed that a profitable business can be done in supplying factories with power in this way. The distances from the site of the proposed dam to the cities named are less than those which have been successfully covered by electric transmission in Germany and Switzerland.

THE dam of the Honey Lake Valley Land Company at Long Valley, Cal., was carried away recently for the second time. The water rose rapidly after a heavy rain, and began to run over the crest of the dam, and in a few minutes cut out a gap 100 ft. wide. The accounts of the failure are not full, but it is said that poor construction and insufficient allowance for overflow had much to do with it.

THE total shipments of iron ore from the Lake Superior region by water during the season just closed were 8,485,210 tons; an increase of 32 per cent. over last year, and of 5 per cent. over 1890, which was a year of very large production. This does not include the rail shipments, which are not yet fully reported, but which are expected to reach 1,000,000 tons.

THE Chinese Viceroy Chang Chih-tung has established large iron works near Hankow, on the banks of the Yang-tse-Kiang River. Iron ore is brought about 80 miles down the river, and coal about 17 miles by a railroad lately built to the mines. At these works a rolling mill for the manufacture of rails is being put in, and they are also to be provided with the necessary tools for the manufacture of small arms and rapid-fire guns of different patterns.

THE surveys are in progress for an irrigation canal to run from Lake Tulare northward to the San Joaquin River near Mendota, Cal. The canal will be about 80 miles long, and will supply water for irrigation to a large area of land in the San Joaquin Valley. The intention is to use Lake Tulare for a storage reservoir.



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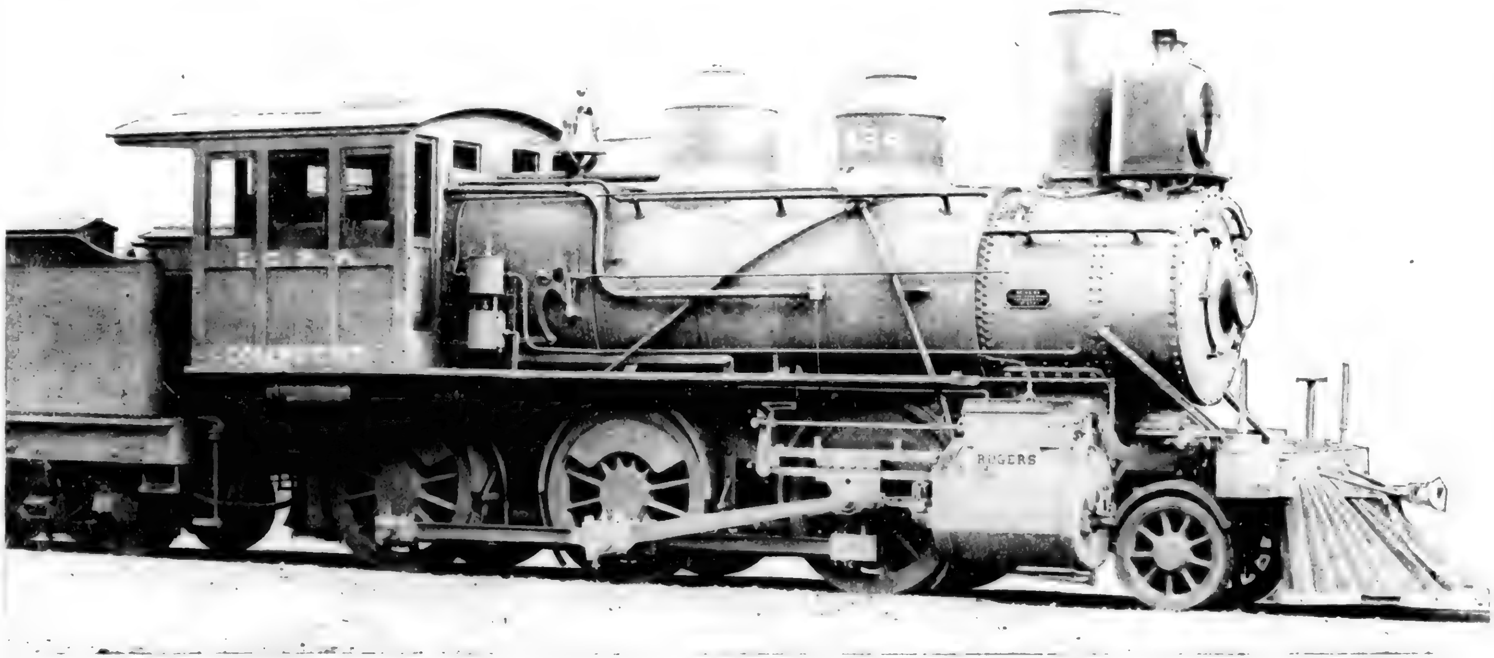

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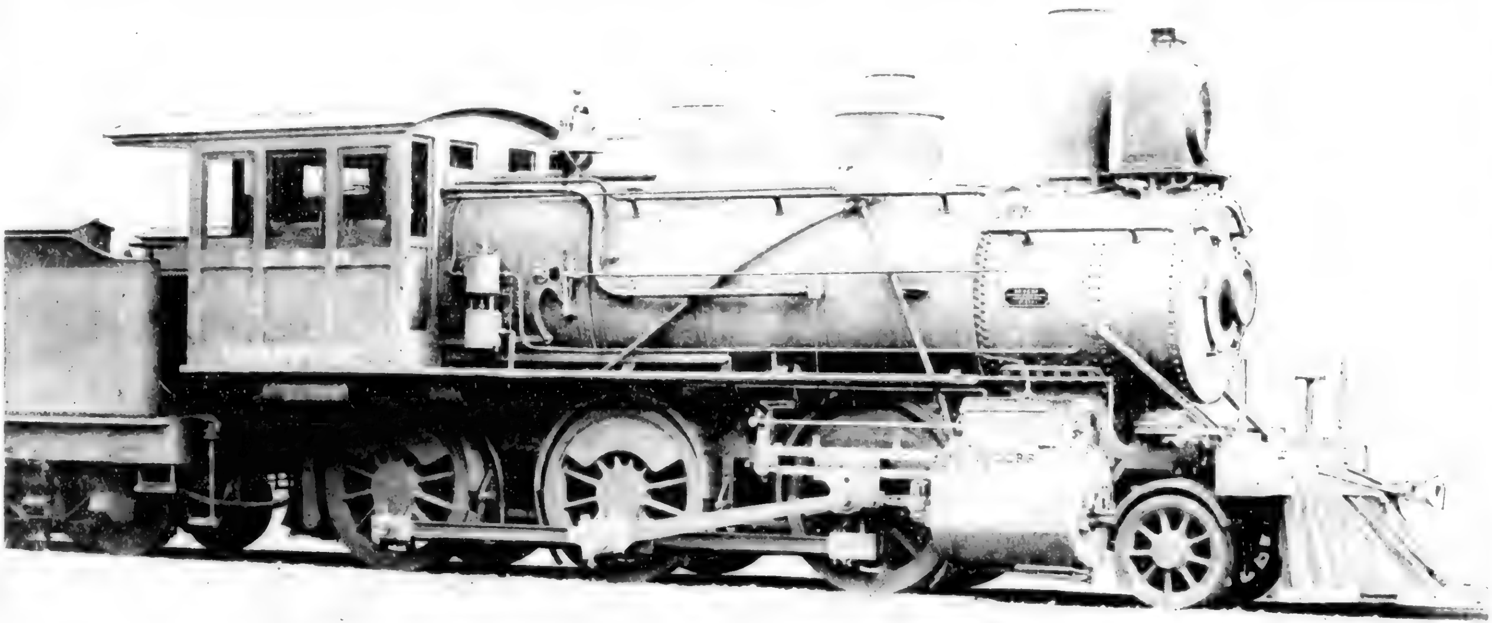

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EXTRACTS FROM CORRESPONDENCE IN OFFICE OF THE DELAWARE & HUDSON CANAL COMPANY.

S. Flewwelling, Treasurer, to John Bolton. Dated New York, January 17, 1829.

"The locomotive engine made by Stephenson & Company has arrived, and I regret that Mr. Allen is not here to direct about taking it from the ship and placing it in a proper situation for putting it up."

S. Flewwelling, Treasurer, to John B. Jervis. Dated New York, January 20, 1829.

"The locomotive engine made by Stephenson & Company, which is the most expensive one, has arrived."

S. Flewwelling, Treasurer, to W. & J. Brown & Company (of Liverpool). Dated New York, February 7, 1829.

"The locomotive engine shipped by your request by Edward F. Starbuck, agent from London, on board the ship *Columbia* in November last has been received."

S. Flewwelling, Treasurer, to W. & J. Brown & Company (of Liverpool). Dated New York, March 6, 1829.

"Mr. H. Allen, when in England, contracted with Messrs. Foster & Rastrick for three locomotive engines, which were to have been shipped shortly after he sailed for this country. As a considerable time has elapsed since we had reason to expect their arrival, and it being very important that they should be sent on as early as possible, I have to ask the favor of you to inquire of Messrs. Foster & Rastrick when these engines will be forwarded, and that you will be pleased to inform me of the result of your inquiry.

"Mr. Allen is now in the country. Had he been here I would have requested him to write to the makers direct."

S. Flewwelling, Treasurer, to Messrs. W. & J. Brown & Company (of Liverpool). Dated New York, April 23, 1829.

"On the 6th of March last I wrote you, requesting you to inquire of Messrs. Foster & Rastrick when the three locomotive engines ordered by Mr. Allen last fall would be completed, and to inform me of the result of your inquiry. They have been expected by every ship that has arrived here from Liverpool for some months, as one of them was nearly completed when Mr. Allen left England in October last, and the two others were to have been finished, and the whole shipped in a short time after his departure, and we are greatly disappointed in their not having yet arrived. The reasons for this delay we are unable to account for, but it is certain the makers have not performed their contract. I have to request that you will immediately employ a competent person, at our expense, to go to Messrs. Foster & Rastrick and insist upon the three locomotive engines ordered by Mr. Allen being finished with all dispatch, and to superintend and see that they are made in the shortest time possible and forwarded to you, that they may be shipped for this place immediately thereafter.

"You will perceive the necessity for my urging your particular attention to this business when you are informed of the importance of the work on which these engines are to be employed. They are for the transportation of coal on our railroad, which is the principal article to be conveyed on our canal of 105 miles in length. The canal is finished, and the railroad with its machinery is expected to be completed early in the month of June next. Without the locomotive engines the whole will be in a great degree inoperative, and all delay in receiving them after the other part of the work is ready for the transportation of the coal will be the loss of the income from a work which will have cost upward of two millions of dollars."

John Bolton to John B. Jervis. Dated New York, May 13, 1829.

"One of the locomotives was to be shipped in the *John Jay*, then in Liverpool, and she is daily expected. The other two are promised, one in 3 and the other in 5 weeks from 8th April. They pretend that an accident to their works has caused the delay. So I yet hope they may reach us in time."

John Bolton to W. & J. Brown & Company (of Liverpool). Dated New York, May 14, 1829.

"I have the pleasure of acknowledging your favor of the 16th ulto. covering a letter from Messrs. Foster, Rastrick & Company, of the 8th, assigning reasons for the delay in execution of their contract for steam-engines, and fixing the time for their deliverance. I trust they will perform their new engagement strictly, but the slight manner in which they notice the lapse of 5 months since the time they engaged to make the delivery does not, I confess, afford strong ground of confidence. Our work is now nearly ready to receive the engines, and so great would be the sacrifice if disappointed that we had determined on sending Mr. Allen out immediately, and should have done so by this packet if I had not received your favor of the 16th. . . . .

"The *John Jay* arrived yesterday with one of the steam-engines."

S. Flewwelling, Treasurer, to Messrs. W. & J. Brown (of Liverpool). Dated New York, May 15, 1829.

"By the arrival of the *John Jay* we have received one of the locomotive engines, and your account is credited £498 18*s*. 3*d*. for the amount of the invoice and the insurance notes enclosed in your letter to the President of the 7th ulto."

W. & J. Brown & Company to John Bolton. Dated Liverpool, May 22, 1829.

"By the packet of 16 ult. we wrote you, and handed a copy of a letter from Messrs. Foster, Rastrick & Company, stating that one engine would be sent off in three weeks, and the other in five weeks or sooner if possible. Their letter was dated 8th ult., but six weeks have now elapsed, and we have no further accounts of them. We have again written to these gentlemen requesting to know distinctly what we are to expect; and if their reply is not entirely satisfactory, we will, as you suggest, send a competent person to their works to see that no further unnecessary delay takes place."

S. Flewwelling to John Bolton. Dated New York, June 23, 1829.

"The two canal boats arrived here on Sunday, and one of them has been left at the dock near Kimble's; the other was to be taken round to Abeel & Dunscomb's to-day. Mr. Allen understood from Mr. Jervis that the locomotive engines were not to be sent up until the breach at the Pulpit (?) was repaired, of which Mr. Jervis was to advise him; and thinks if they are sent this week, the boats will be delayed some time with the engines in them."

S. Flewwelling to John Bolton. Dated New York, July 1, 1829.

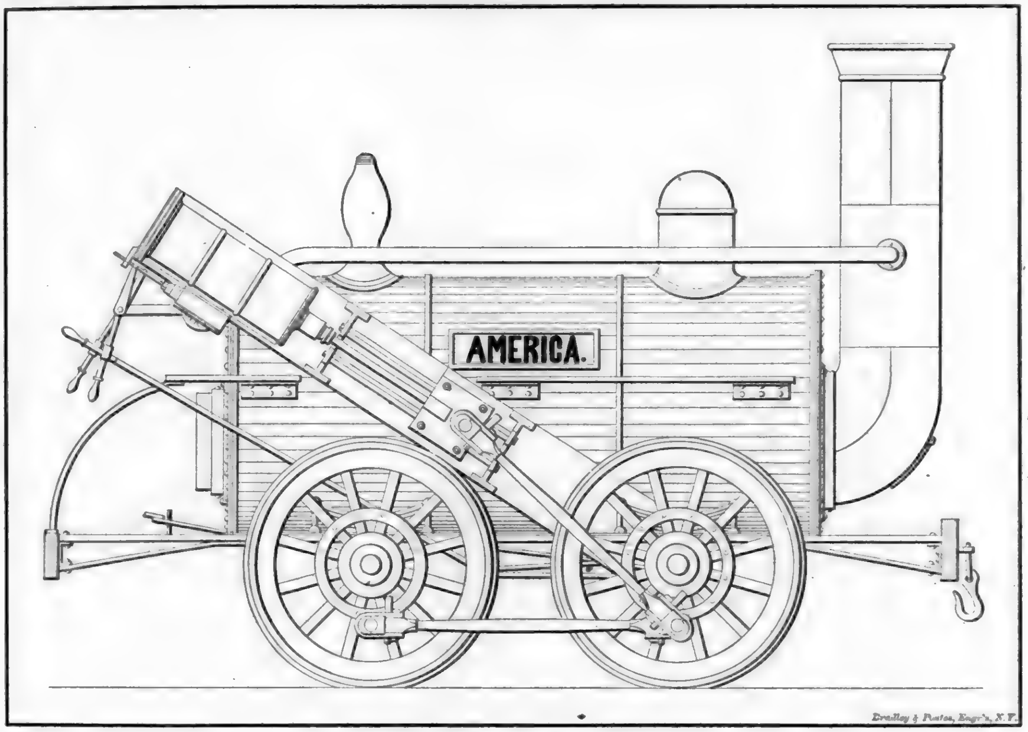
"The locomotives will be put on board the *Congress* to-morrow, and the canal boat will be loaded with wheels, and (?) towed up."

S. Flewwelling to John B. Jervis. Dated New York, July 2, 1829.

"Mr. Allen is putting the locomotive engines on board the *Congress*, that goes up to-day, and he goes on her to Kingston."

S. Flewwelling to J. B. Jervis. Dated New York, July 22, 1829.

"By the arrival of the *Britannia* I have just received a letter from Messrs. W. & J. Brown & Company, of Liverpool, in which they say: 'We have received from Messrs. Foster, Rastrick & Company an invoice for the 2d locomotive engine—amt. £488—which they inform us has been sent off, and we have no doubt it will be here in time for shipment by the packet of 8th proxo. The other, they say, will be forwarded in ten days.' That letter from W. J. B. &



LOCOMOTIVE ENGINE "AMERICA."

BUILT BY R. STEPHENSON & COMPANY, NEWCASTLE-ON-TYNE, FOR THE DELAWARE & HUDSON CANAL COMPANY, TO THE ORDER OF MR. HORATIO ALLEN, IN 1828.

Company is dated the 29 May, and the packets of the 8th and 15th of June are daily expected which may bring both of the engines."

S. Flewwelling to J. Bolton. Dated New York, July 29, 1829.

"We are again disappointed in the locomotive engines not being on the *Silvanus Jenkins.* A letter of the 8th of June from W. & J. Brown & Company says:

"'The locomotive engine has been here several days; but the packet having had but little time to load we could not induce the Cap't to take it owing to the difficulty of getting it on board. We then engaged to ship it by the *Thos. Dickerson* to sail 12th inst., but the master has just called to say that in measuring his hatchway he finds the boiler is too large to go down it, and we shall now endeavor to get it on board the *New York*, to sail 16th inst.'"

S. Flewwelling, Treasurer, to J. Bolton. Dated New York, July 31, 1829.

"The *New York* has arrived without the locomotive engine, but letters are received from Messrs. Brown, saying that it is on board the *Splendid*, to sail on the 20th June."

S. Flewwelling, Treasurer, to J. Bolton. Dated New York, August 3, 1829.

"I omitted to mention that a copy of a letter from John U. Rastrick was enclosed in the letter rec'd from W. & J. Brown & Co., in which he says:

"'The last engine would have been sent off last week, but as I have made some very important additions and improvements to our locomotive engines that we started the 2d inst., I determined to alter the one on hand; we are now adding these, and I shall also send the additional parts for the two engines already sent off free of any additional charge, being desirous to make them as perfect as possible, and when I have written Mr. Allen, from whom I have had a letter, and sent him the drawings and details, I know he will feel I have done everything for their advantage, and that the delay of a few months will be amply compensated for by the improvements of the engines. I will send the whole off in ten days.'" (*Dated June* 13, 1829.)

S. Flewwelling, Treasurer, to Messrs. W. & J. Brown & Company (of Liverpool). Dated August 7, 1829.

"In the copy received of the letter from Messrs. Foster & Rastrick they give a reason for the delay in completing and forwarding the locomotive engines, which they appear to hope will be satisfactory. They cannot, however, be insensible of the great responsibility they have assumed in extending the time six months beyond the period at which they contracted to deliver them; and it is a subject of surprise that they should conceive any improvement made in the engines could warrant or excuse so great a delay in their delivery.

"The engine shipped on the *Splendid* has not yet arrived, and at present we cannot calculate the injury we may sustain from the delay."

S. Flewwelling, Treasurer, to W. & J. Brown & Company (of Liverpool). Dated August 15, 1829.

"The locomotive engine, by the ship *Splendid*, is received with your letter of the 19th of June last, covering invoice

and bill of lading; and your account is credited £503 2*s.* 7*d.*, the amount of the invoice and the cost of insurance."

S. Flewwelling, Treasurer, to John Bolton. Dated September 6, 1829.

"The locomotive engine is on board the *Cornelia;* but could I have known that she would have been so deeply loaded, I should have sent it by the steamboat on Thursday. Capt. Goetchies (?) says there is no hazard; but I shall feel anxious until I hear of its safe arrival, although the wind is moderate, with the prospect of its being fair."

S. Flewwelling, Treasurer, to M. Wurts, Agent. Dated September 12, 1829.

"The day before yesterday a report was circulated here that the locomotive engine called the *Lion* had by accident been run off the railroad and dashed in pieces. I am glad you mentioned the accident of the wagon running off the road, as it gave me an opportunity of explaining the cause of the report."

S. Flewwelling, Treasurer, to John Bolton. Dated New York, September 15, 1829.

"Mr. Lord has returned, and says he had the pleasure of seeing you at Kingston. All the persons with whom I have conversed, who have witnessed the moving of the locomotive engines on the railroad, say that they cannot perceive that the iron plates are pressed out of place so as to be any way injurious, and could not discern any damage which they considered important, even after it was pointed out to them."

S. Flewwelling to John Bolton. Dated New York, September 18, 1829.

"The *John Jay* arrived yesterday, and brings the last locomotive engine. When landed, I shall send it up unless instructed to the contrary."

S. Flewwelling to John Bolton. Dated New York, October 21, 1829.

"Mr. Dunscomb has put the boiler of the locomotive engine on board the sloop *Forrester*, Captain Betts."

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.*

I.—PHOSPHORUS IN STEEL—*Continued.*

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page 550, Volume LXVI.*)

With regard to the method given in the last number, a few words in explanation of the reasons why certain modes of procedure and certain reagents were chosen, rather than others which are likewise in use by good chemists, may perhaps not be amiss.

We have no doubt that many chemists will think that one gram is a small amount to work on, and would prefer to work on a larger amount of steel, thus reducing the possible error. Our decision to use one gram is based on this. There is a belief, possibly not fully demonstrated, that the complete separation of phosphoric acid from iron is difficult, if not quite impossible, by means of molybdic acid. When we say complete separation we mean the very last and most minute trace. If our memory serves us correctly, eminent chemists have affirmed that such separation was impossible; and the published work of Dr. J. Lawrence Smith—notably his article in the *American Journal of Science*, third series, Vol. XXII, p. 316—seems to indicate that the separation of phosphoric acid from iron is most complete when the proportion of molybdic acid to the iron in the solution in which the yellow precipitate is formed is large. Furthermore, we made this experiment—namely, we took a neutral water solution of chloride of iron and a neutral water solution of molybdate of ammonia, and on mixing these a precipitation ensued of apparently white molybdate of iron, which precipitate is readily soluble in nitric acid. We are inclined to think, therefore, that when the molybdate solution is added to the iron solution in the regular phosphorus determination, molybdate of iron is formed, and that the chances of a complete separation of phosphoric acid are greater, provided the amount of molybdic acid is sufficient to convert all the iron into molybdate. But with the molybdate solution at present in use this result cannot be accomplished without an excessive amount of the molybdate solution, and a very large dilution of the menstruum in which the yellow precipitate is formed, if we start with 2 grams of steel. With the method as we have given it the amount of molybdic acid in the 75 cubic centimeters of molybdate solution is sufficient to convert all the iron into molybdate, and leave a quite considerable excess of molybdic acid to combine with the phosphorus. There are some indications that low results when using the molybdate method may be explained in this way—namely, starting with 5 or 10 grams of steel and only adding the ordinary amount of molybdate solution, the separation of phosphoric acid is possibly not complete. Another series of experiments which we tried also proved instructive. We took a certain amount of nitrate of iron solution containing phosphorus and added 5 cubic centimeters of molybdate solution which contained twice as much molybdic acid as was necessary to precipitate all the phosphorus, everything being done to secure the most favorable conditions for the formation of the yellow precipitate. No yellow precipitate was formed in some time. We then added 5 cubic centimeters more without any precipitation, and so proceeded until we had added 25 cubic centimeters, when the precipitate began to form, and ultimately all the phosphorus came down. Another series with the normal amount of nitrate of ammonia present before adding the molybdate solution showed similar results. Apparently, therefore, a certain amount of molybdate solution, in excess of what is necessary to form the yellow salt, is essential before the yellow precipitate will form in presence of nitric acid and nitrate of iron. Just exactly where the limit is it would require further work to demonstrate; but in view of the uncertainty, we decided on such proportions of metal to start with and of molybdate solution as would convert all the iron and still leave enough molybdate to combine with the phosphoric acid. One consideration further, the permanganate solution given in the method above is of such strength that even though an error of 0.10 cubic centimeter should be made in the readings at the final titration of the molybdic acid, the error introduced by this 0.10 would be but a trifle over 0.0005 per cent. Since, therefore, it is easy to read burettes as close as 0.10, we are inclined to think that the error introduced, even in steels very low in phosphorus, by working on one gram can be safely ignored.

It will be noted that, in the course of the method as described, it is stated that the specific gravities of the solutions are essential. It seems to be generally agreed that the concentration of solutions, the bulk of the solutions, the temperature of precipitation, the amount of free acid present, and also the amount of other salts present, all have an influence on the composition of the yellow precipitate, also that if these conditions are made constant, a yellow precipitate of constant composition or practically so is obtained. It would be, perhaps, too much to say that we have ourselves made experiments to demonstrate each one of these points. We find these points claimed, with more or less demonstration accompanying them, in the literature of the

* The first series of these articles was published in The Railroad and Engineering Journal, December, 1889–June, 1892. The present article is the third of a new series; the first of these was introductory, the second on the same subject as the present one.

method, and our experience is limited more especially to the last clause—namely, if we make the conditions constant we have no difficulty in getting uniform results working on the same steel. Duplicate, triplicate and quadruplex determinations on the same steel, on different days, and with different steels, rarely differ more than 0.002 per cent. or 0.003 per cent. on very low steels, provided the directions are carefully followed and the conditions made uniform. Many duplicates show the same result even to 0.001 per cent. It is only, however, by having all the conditions constant that such results can be obtained, and this is why so much importance is attached to the specific gravities of the solutions. It is very interesting to note that dilute nitric acid, even so dilute as 1.135 specific gravity, gives exactly the same results as if concentrated nitric acid was used for the first solution, as we have proven by duplicate determinations on the same sample, using the different gravities of nitric acid to start with. It seems probable that the reaction between the steel and the nitric acid is a complicated one, resulting in the formation of several products. Apparently one of the first reactions, especially if dilute acid is used, is to form a proto-nitrate of iron. The subsequent boiling of the solution after the steel is dissolved converts this, with decomposition of some of the free nitric acid, into the sesqui-salt; and if this boiling is carried out as the directions state, much less of the permanganate will be used in the subsequent oxidation than if the solution is not boiled. It is barely possible that the action of the permanganate may not be completely understood, and there seems a threefold action possible: first, to convert any proto-nitrate of iron that may be left, into the sesqui-salt; second, to oxidize the carbon in the nitric acid solution; and, third, to completely oxidize the phosphorus to phosphoric acid. It is believed that the directions cover the complete oxidation for all steels, but it is obvious with steels containing large amounts of carbon, such as spring steel and tool steel, more oxygen will be used up from the nitric acid and permanganate than from steels containing small amounts of carbon.

The desirability of securing the necessary oxidation of the iron salt and of the carbon, and possibly of the phosphorus to phosphoric acid, by permanganate rather than chromic acid, is a question about which there may be some difference of opinion. In our experience the permanganate seems to accomplish the result fully as satisfactorily as the chromic acid, and does not introduce any free acid into the solution. We have not made exhaustive experiments on the use of these two oxidizing agents, but the method which is especially characterized by the use of chromic acid requires evaporation, which is not essential in the method which we have recommended. Moreover, as will be stated a little later, the amount of free acid present we think has an influence on the composition of the yellow precipitate, and possibly on the amount of it; so that since we can secure the result desired by the addition of the neutral salt, we think it safer and better in every way to do this than to use the free chromic acid. This peculiarity—namely, the use of permanganate instead of chromic acid—is one of the principal differences between the method as we recommend it and Wood's method, which has already been published and largely used. This perhaps is the place to give another reason why we prefer the method as published to Wood's method—namely, in addition to the greater ease and equal certainty obtained by the use of permanganate, we are inclined to think the method that we recommend gives more readily obtained constant conditions than Wood's method. With the latter a certain amount of evaporation to approximately certain bulk of the nitric acid solution is requisite. In our experience, covering now two or three years, we find it very difficult to get uniform conditions as to free nitric acid present with this evaporation. The evaporation itself is a disagreeable operation, is conducted in a beaker not capable of accurate measurement, and results in very concentrated nitric acid, so that a small error of bulk makes a wide difference in the amount of free nitric acid present in the subsequent operation. We have obtained excellent results with Wood's method, but we think the labor and uncertainty of the method are greater than of the method which we recommend.

The amount and strength of the nitric acid used to dissolve the steel and the subsequent manipulation and use of the solution have been designed in such a way that after the molybdate solution is added the percentage of free nitric acid in the resulting solution is the same as in the molybdate solution itself. Our reasoning was this: It is believed that the yellow precipitate is more insoluble in the molybdate solution than in any other known menstruum, and the insolubility of the yellow precipitate is affected by the amount of free nitric acid. We therefore base our quantities and manipulation so as to secure a final solution in which the yellow precipitate should be formed that would have the same amount of free nitric acid as the molybdate solution. Of course if a molybdate solution can be made in which the yellow precipitate is more insoluble than the one given in the method as published, it would be a step forward. At present, and until further work is done on this point, our method as published rests, so far as the insolubility of the yellow precipitate is affected by free nitric acid, on the amount of free nitric acid in the standard molybdate solution. We of course recognize that the nitrate of iron may have an influence on the insolubility of the yellow precipitate, and our only point here is that, as stated above, so far as the insolubility of the yellow precipitate is affected by the free nitric acid, the method as given assumes that the molybdate solution contains that amount of free nitric acid in which the yellow precipitate is most insoluble.

Those who are familiar with the literature of phosphorus determinations will remember that it has been recommended to reduce the molybdic acid in a flask or beaker by treatment with granulated zinc, and it will be observed that instead of this procedure, we pass the liquid through a reductor containing powdered zinc. We have used both methods, and our experience very greatly favors the reductor method with the powdered zinc. Even with platinum and a little mercury present for amalgamation, the very last portion of the reduction is extremely slow with granulated zinc, and it is difficult to completely discharge the port-wine color. Even a few minutes' standing after the liquid is poured off from the granulated zinc before titration will give this color, indicating incomplete reduction of the molybdic acid. On the other hand, with the reductor the reduction is apparently complete within the first half inch of the powdered zinc in the top, and we have never had the slightest difficulty with any subsequent oxidation. We have run across some parties who claimed that they did not get good results with the reductor, but this is so contrary to our experience that it is difficult for us to see why. We will say, however, that if the yellow precipitate is washed in nitric acid, or in a wash-water containing nitrates, or if all the nitrates are not washed out of the yellow precipitate, there will be trouble subsequently with the reductor. The deleterious effects of nitric acid can be readily demonstrated by any person for himself, by adding a drop or two of nitric acid to dilute sulphuric acid, and passing it through the reductor simply as a blank, followed by subsequent titration. Of course, when nitrates are treated with sulphuric acid, free nitric acid results, producing the same effect. The amount of permanganate used up by even a single drop of nitric acid, under the conditions above, will, we think, astonish any one who has not made the experiment.

It is probable that many chemists will prefer to dry and weigh the yellow precipitate instead of titrating with permanganate, as we recommend, and it is only fair that the reasons which led us to choose the permanganate method should be given. There are two reasons. We may say preliminarily that we have obtained almost identical results by both methods, but in our experience the weighing of any substance on the dried filter is always an operation attended with uncertainty, especially unless one has had a good deal of experience. We have also obtained very satisfactory results by catching the yellow precipitate in a Gooch crucible on an asbestos filter, but find at the best that the gradual change of a dried filter, or a Gooch crucible, during the operation of weighing, is sufficient in our experience to introduce a little feeling of uncertainty as to results. There is another consideration which has some influence here—namely, in steels containing 0.20 to 0.30 of silicon there is always a danger of weighing a little silicon with your yellow precipitate. In view of these uncertainties and in view of the fact that almost every laboratory has or should have a standard permanganate solution which can be easily stand-

ardized and easily kept standard, we finally decided, after a good deal of study and thought, to use the permanganate method. If the reductor is kept in good order and the laboratory has a supply of standard steel or iron, proper care being taken to secure good permanganate of potash and to age it properly before it is used, there are few reagents, if we may trust our experience, that are more satisfactory than permanganate solution.

The end reaction in washing the yellow precipitate may possibly need a word or two of explanation. It will be observed that the directions practically require to allow a few drops of the washings from the funnel to fall into a dilute sulphide of ammonium solution. The wash-water is acid, and the sulphide of ammonium more or less alkaline. It is obvious, therefore, that there may arise two conditions. Enough wash-water may run in to change the sulphide of ammonium solution into an acid solution, or only enough washings may run in to still leave the sulphide of ammonium alkaline or neutral. Under which condition is the greater sensitiveness obtained? Some chemists prefer the acid condition; but our directions call for the alkaline condition, which we prefer, and for the following reason: If we are testing for molybdenum, it is obvious that the acid solution should be used, since molybdenum forms no precipitate in the alkaline solution, but simply changes color slightly. If we are testing for iron, no precipitate or change of color is formed in the acid solution, but a marked change of color results in the alkaline solution. In view of the fact that the yellow precipitate is believed to be slightly soluble in the wash-water if we test for molybdenum, it is obvious we would never get an end reaction, provided the test is sufficiently delicate. On the other hand, we are washing out of the filter molybdate of iron, and when the molybdate of iron is out it is perhaps safe to assume that the filter is washed clean. We accordingly prefer that manipulation which shows the iron, especially since the molybdenum present assists the change of color, even in the alkaline solution.

The use of sugar and other organic substances to reduce the binoxide of manganese formed during the process of solution and oxidizing the phosphorus has been proposed. It will be observed that we prefer to use proto-sulphate of iron. It is claimed that there is not much difference between the action of these various substances; and as the amount is quite small, it is probable that the results will not be seriously affected whichever reducing agent is used. We prefer the proto-sulphate of iron, as we do not like to introduce into a steel solution, where we have been trying to get rid of the organic matter, any organic substance. Of course a very large amount of sulphate of iron might produce sulphates enough to interfere with the successful subsequent precipitation of the yellow precipitate, but there seems little danger of this if the directions are followed.

Some questions may arise in regard to the calculations. There is a good deal of variation in the literature of the phosphorus method as to the composition of the yellow precipitate. Our own explanation of these variations is that probably the composition of the yellow precipitate is affected by the conditions under which it is formed. Our figure showing the relation of phosphorus to molybdic acid was obtained as follows: We took three samples of steel, one containing about 0.15 per cent. carbon, one containing about 0.55 per cent. carbon, and another containing about 1.00 per cent. carbon. We made careful phosphorus determinations on each of these three samples by what is known as the combination method—that is, starting with 10 grams, we separated arsenic, and proceeded exactly as described under the acetate method in the "Chemical Analysis of Iron," by A. A. Blair (second edition), up to the point of obtaining the basic acetate precipitate, except that instead of adding two or three drops of bromine to oxidize iron enough to carry down the phosphorus, we added enough bromine to oxidize one-half gram of the iron. This half gram, after being washed on the filter, was treated with nitric acid and the phosphorus separated from it by means of molybdic acid. The yellow precipitate obtained from this precipitation was then dissolved in ammonia and the molybdic acid converted into the sulphide in alkaline solution by passing sulphuretted hydrogen gas, after which the molybdic acid was separated by acid and removed by filtration. In the filtrate concentrated to a very small bulk, the phosphorus was precipitated by magnesial mixture. The results obtained from these analyses were regarded as the amount of phosphorus contained in the three steels, and the factor used in the volumetric method was based on these analyses.

Within the last year a method of treating the yellow precipitate different from that which we recommend was published by Mr. J. O. Handy, Pittsburgh, which consisted practically in dissolving the yellow precipitate in caustic soda, and titrating the excess of soda by means of nitric acid, using phenolphtaline as the indicator. This method has been received with a good deal of favor, and, according to our experiments, gives practically the same results as the method which we recommend. Two reasons, however, led us not to adopt this in preference to the permanganate treatment of the yellow precipitate: first, it is more difficult to secure standard solutions of caustic soda and nitric acid than it is to secure a standard solution of permanganate of potash. Starting with metallic iron, the strength of the permanganate solution is easily and quickly obtained, and the same solution is used in almost every laboratory for other purposes. The Handy method requires the maintenance of two special solutions not useful for other purposes. There is another phase of the case—namely, phenolphtaline is not delicate in presence of ammonia salts; and while the solutions can be so manipulated that this difficulty is small, provided the amount of yellow precipitate titrated is small, we are inclined to fear that with high phosphorus, considerable difficulty would result; so we really saw no advantage in this over the permanganate method, while what advantage there is seems to be the other way, and accordingly we chose the permanganate method.

Also during the past year Mr. H. C. Babbitt, Chemist of the Wellman Iron & Steel Company, Thurlow, Pa., proposed a modification of the method of getting the yellow precipitate, which is claimed to eliminate the co-precipitation of the arsenic with the phosphorus. The method consists practically in precipitating at a temperature not above 25° centigrade. We think it has been taught in some of the schools for a considerable time past that the chances for carrying down arsenic along with the phosphorus by means of molybdic acid were diminished at low temperatures, but it has also been taught that in order to secure a complete precipitation of the phosphorus under these circumstances it was essential to have considerable time. Mr. Babbitt's paper would seem to claim that even at low temperatures and short time, phosphorus might be completely precipitated with the avoidance of the co-precipitation of the arsenic. We have not been able to do much positive work on this question. A little work on a single sample of steel known to contain quite considerable arsenic with considerable phosphorus, does not confirm the view that the phosphorus is completely precipitated at low temperatures and in short time. Further work should be done on this point, and it is fair to say that the question of how to secure the phosphorus in steel by any rapid method without the arsenic interfering, so far as our knowledge goes, is not at present satisfactorily answered. In view of this state of affairs, we decided to take the other horn of the dilemma—namely, to call all that comes down by the method which we have published phosphorus, recognizing at the same time that in steels containing considerable arsenic there is a strong probability that a portion of the material called phosphorus is arsenic. It is barely possible that within the next six months or a year some method of overcoming this difficulty may be devised. It is to be regretted that there is so little positive knowledge of the influence of arsenic on steel. The best authorities that we can consult indicate at least that arsenic is not so harmless an element in steel that it can be ignored, also that its influence is much the same as that of phosphorus; so that, in view of the fact that the steel-makers are forewarned that arsenic will be counted against them, we think no hardship can result.

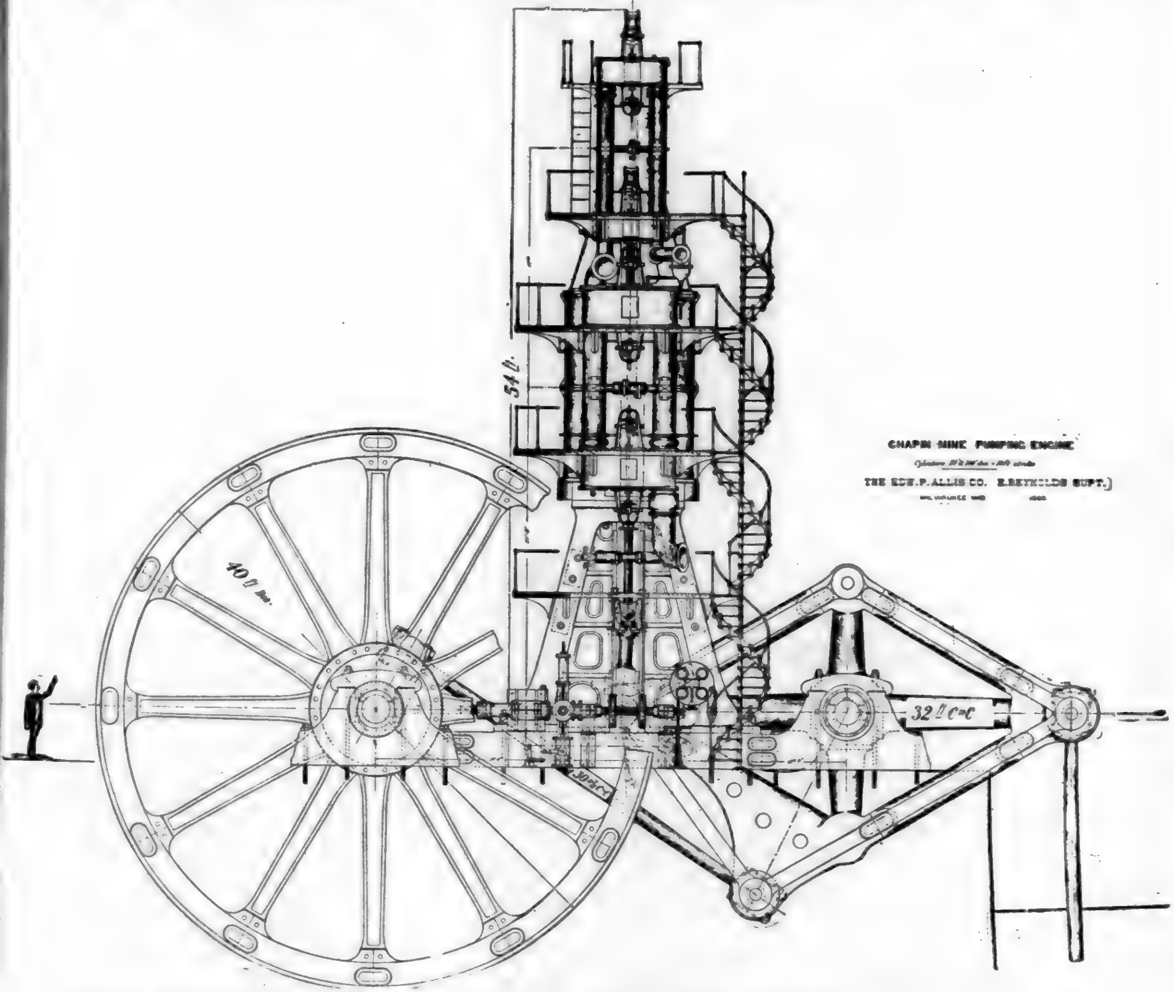
It will be observed that the method as published is not recommended to be used for pig iron, nor have we experimented with it on ores. It is to be hoped that enough work will be done in the near future to not only check up whatever weak points there may be in the method as it now exists, but also to expand its application.

(TO BE CONTINUED.)

A LARGE PUMPING ENGINE.

THE engraving given herewith is from a drawing of an engine which is notable not only for its large size, but also for the special adaptation of its design to the work which it is intended to do. It was recently built by the Edward P. Allis Company in Milwaukee, Wis., for the Chapin Mining Company of Iron Mountain, Mich. It is a compound type. The cylinders have poppet valve-gear with a trip cut-off on the high-pressure cylinder and a Stevens cut-off on the low-pressure cylinder. There is an independent steam-power air pump and a surface condenser; in the latter, part of the water raised from the mine will be used for condensing purposes.

A peculiar feature of this engine is that the cylinders and valve-gear are so proportioned and arranged that the engine can be run by compressed air instead of steam, if desired.



engine of the steeple pattern and is designed to raise water up a vertical shaft from a depth of 1,500 ft.

The work will be done by plunger pumps placed in the shaft about 200 ft. apart. These pumps have plungers 28 in. in diameter and 10 ft. stroke; the plungers are connected and driven by a steel rod 7 in. in diameter extending to the bottom of the shaft and working in guides placed about 20 ft. apart. At its upper end this driving-rod is connected to the beam shown in the engraving, from which it receives a reciprocating motion, and which is, in turn, driven directly by the engine.

As before noted, the engine is of the compound type; the high-pressure cylinder is 50 in. in diameter and 10 ft. stroke, and the low-pressure cylinder 100 in. in diameter and 10 ft. stroke. The ratio of the cylinders is 1 : 4. The engine is designed to work with 125 lbs. pressure. Steam will be supplied by vertical tubular boilers of the Reynolds

In running with air the large or low-pressure cylinder would be used as the initial cylinder. The Chapin Company has a plant of large capacity at Quinnesec Falls, where air is compressed by water-power, and from this plant the engine can be supplied, should it be decided to dispense with steam.

The great size and capacity of the engine will be better understood from some of the details. The journals of the main shaft and of the beam centers are 24 in. in diameter and 36 in. long. The crank-pin, crosshead-pin, and the pins on the beam have bearings 16 in. in diameter and 18 in. long. The connecting-rod is 30 ft. in length and is 15 in. in diameter at the center. The fly-wheel is 40 ft. in diameter and weighs 160 tons. The main beam is 32 ft. between centers, and its weight complete is 100 tons. The total weight of the engine, including only the parts shown in the engraving, and excluding the pumps and other work

in the shaft, is 600 tons. Its total height above the engine-room floor is 54 ft. It is one of the largest stationary engines in the country and is expected to do notable work.

This engine is all in place and erected at the mine, and will be started up as soon as the work on the pumps in the shaft is completed. The depth of the main shaft of the mine is now 600 ft., and three sets of pumps are in place. Additional pumps will be added as the shaft is sunk deeper.

The works of the Allis Company have turned out many engines of large dimensions which are now doing excellent work.

CYLINDER CONDENSATION AND STEAM-ENGINE ECONOMY.

(From address of W. Cawthorne Unwin, F.R.S., President of Mechanical Science Section, at the Annual Meeting of the British Institution.)

With the knowledge he had acquired of the relations of the pressure and temperature of steam, its volume at different pressures, and the heat absorbed in producing it, James Watt was able to determine that the quantity of steam used in a model atmospheric engine was enormously greater than that due to the volume described by the piston. There was waste or loss. To discover the loss was to get on the path of finding a remedy. The separate condenser, by diminishing cylinder condensation, annulled a great part of the loss. So great was Watt's insight into the action of the engine that he was able to leave it so perfect that, except in one respect, little remained for succeeding engine builders, except to perfect the machines for its manufacture, to improve its details, and to adapt it to new purposes. Now it very early became clear that there were two directions of advance which ought to secure greater economy. Simple mechanical indications showed that increased expansion ought to insure increased economy. Thermodynamic considerations indicated that higher pressures, involving a greater temperature range of working, ought to secure greater economy. But in attempting to advance in either of these directions, engineers were more or less disappointed. Some of Watt's engines worked with 5 lbs. of coal per indicated horse-power per hour. Many engines with greater pressures and longer expansions have done but little better. The history of steam-engine improvement for a quarter of a century has been an attempt to secure the advantages of high pressures and high ratios of expansion. The difficulty to be overcome has proved to be due to the same cause as the inefficiency of Watt's model engine. The separate condenser diminished, but it did not annul, the action of the cylinder wall. The first experiments which really startled thoughtful steam engineers were those made by Mr. Isherwood, between 1860 and 1865. Mr. Isherwood showed that in engines such as those then in use in the United States Navy, with the large cylinders and low speeds then prevalent, any expansion of the steam beyond three times led, not to an increased economy, but to an increased consumption of steam. Very little later than this M. Hirn undertook, in 1871–75, his classical researches on the action of the steam in an engine of about 150 indicated horse-power. Experiments of greater accuracy or completeness, or of greater insight into the conditions which were important, have never since been made, and Hirn with his assistants, MM. Hallauer and Dwelshauvers-Dery, has determined, once for all, the whole method of a perfect steam-engine trial. M. Hirn was the first to clearly realize that the indicator gives the means of determining the steam present in the cylinder during every period of the cycle of the engine. Consequently, superheating in ordinary cases being out of the question, we have the means of determining the heat present and the heat already converted into work. The heat delivered into the engine is known from boiler measurements, combined with calorimetric tests of the quality of the steam, tests which Hirn was the first to undertake. The balance or heat unaccounted for is, then, a waste or loss due to causes which have to be investigated. Hirn originated a complete method of analysis of an engine test, showing at every stage of the operation the heat accounted for and a balance of heat unaccounted for; and the latter proved to be a very considerable quantity.

Meanwhile theoretical writers, especially Rankine and Clausius, had been perfecting a thermodynamic theory of the steam-engine, based primarily on the remarkable and irrefragable principle of Carnot. The result of Hirn's analysis was to show that these theories, applied to the actual steam-engine, were liable to lead to errors of 50 or 60 per cent., the single false assumption made being that the interaction between the walls of the cylinder and the steam was an action small enough to be negligible.

In England, Mr. Mair Rumley, following Hirn's method, made a series of experiments on actual engines with great care and accuracy and completeness. All these experiments demonstrated the fact of a large initial condensation of steam on the walls of the cylinder, alike in jacketed and unjacketed engines. This condensed steam is reevaporated partially during expansion, but mainly during exhaust, and serves as a mere carrier of heat from boiler to condenser, in conditions not permitting its utilization in producing work.

It became clear from Hirn's experiments, if not from the earlier experiments of Isherwood, that for each engine there is a particular ratio of expansion for which the steam expenditure per horse-power is least. Professor Dery has since deduced from them that the practical condition of securing the greatest efficiency is that the steam at release should be nearly dry. In producing that dryness the jacket has an important influence. In spite of much controversy among practical engineers about the use of the jacket, it does not appear that any trustworthy experiment has yet been adduced in which there was an actual loss of efficiency due to the jacket. In the older type of comparatively slow engines it is a rule that the greater the jacket condensation the greater the economy of steam, even when the jacket condensation approaches 20 per cent. of all the steam used. It appears, however, that as the speed of the engine increases, the influence of the jacket diminishes, so that for any engine there is a limit of speed at which the value of the jacket becomes insignificant.

Among steam-engine experiments directed specially to determine the action of the cylinder walls, those of the late Mr. Willans should be specially mentioned. Mr. Willans' death is to be deplored as a serious loss to the engineering profession. His steam-engine experiments, some of them not yet published, are models of what careful experiments should be. They are graduated experiments designed to indicate the effect of changes in each of the practically variable conditions of working. They showed a much greater variation of steam consumption (from 46 to 18 lbs. per indicated horse-power hour) in different conditions of working than, I think, most practical engineers suspected, and this has been made more significant in later experiments, on engines working with less than full load. The first series showed that in full load trials the compound was superior to the simple engine in practically all the conditions tried, but that the triple was superior to the compound only when certain limits of pressure and speed were passed.

As early as 1878 Professor Cotterill had shown that the action of a cylinder wall was essentially equivalent to that of a very thin metallic plate, following the temperature of the steam; the exceedingly rapid dissipation of heat from the surface during exhaust especially being due to the evaporation of a film of water initially condensed on its surface. In permanent *régime* the heat received in admission must be equal to that lost after cut off. In certain conditions it appeared that a tendency would arise to accumulate water on the cylinder surfaces, with the effect of increasing in certain cases the energy of heat dissipation. Recently Professor Cotterill has been able to carry much further the analysis of the complex action of condensation and reevaporation in the cylinder, and to discriminate in some degree between the action of the metal and the more ambiguous action of the water film. By discarding the less important actions, he has found it possible to state a semi-empirical formula for cylinder condensation in certain restricted cases which very closely agrees with experiments on a wide variety of engines. It is to be hoped that, with the data now accumulating, a considerable practical advance may be made in the clearing up of this complex subject. There are, no doubt, some people who are in the habit of depreciating quantitative investigations of this kind. They are as wise as if they recommended a manufacturer to carry on

his business without attending to his account books. Further, the attempt to obtain any clear guidance from experiments on steam-engines has proved a hopeless failure without help from the most careful scientific analysis. There is not a fundamental practical question about the thermal action of the steam-engine, neither the action of jackets or of expansion or of multiple cylinders, as to which contradictory results have not been arrived at, by persons attempting to deduce results from the mass of engine tests without any clear scientific knowledge of the conditions which have affected particular results. In complex questions fundamental principles are essential in disentangling the results. Interpreted by what is already known of thermodynamic actions, there are very few trustworthy engine tests which do not fall into a perfectly intelligible order.

There is only one known method, not now much used, by which the cylinder condensation can be directly combated. Thirty years ago superheating the steam was adopted with very considerable increase of economy. It is likely that it was thought by the inventor of superheating that an advantage would be gained by increasing the temperature range. If so, his theory was probably a mistaken one. For the cooling action of the cylinder is so great that the steam is reduced to saturation temperature before it has time to do work; but the economy due to superheating was unquestionable, and was very remarkable considering how small a quantity of heat is involved in superheating. The heat appears to diminish the cylinder wall action so much as almost to render a jacket unnecessary. The plan of superheating was abandoned from purely practical objections, the superheaters then constructed being dangerous. Recently superheating has been tried again at Mulhouse by M. Meunier, and his experiments are interesting because they are at higher pressures than in the older trials and with a compound engine. It appears that even when the superheater was heated by a separate fire there was an economy of steam of 25 to 30 per cent. and an economy of fuel of 20 to 25 per cent., and four boilers with superheating were as efficient as five without it.

It may be pointed out as a point of some practical importance that if a trustworthy method of superheating could be found, the advantage of the triple over the compound engine would be much diminished. For marine purposes the triple engine is perfectly adapted. But for other purposes it is more costly than the compound engine, and it is less easily arranged to work efficiently with a varying load.

There does not seem much prospect of exceeding the efficiency attained already in the best engines, though but few engines are really as efficient as they might be, and there are still plenty of engines so designed that they are exceedingly uneconomical. The very best engines use only from 12 to 13 lbs. of steam per indicated horse-power hour, having an absolute efficiency reckoned on the indicated power of 16 per cent., or reckoned on the effective power, 13 per cent. The efficiency, including the loss in the boiler, is only about 9 per cent. But there are internal furnace engines of the gas-engine or oil-engine type in which the thermal efficiency is double this.

THE LAKE CHANNEL.

THE Cleveland *Marine Record* states that the contracts for the completion of the 20-ft. channel from Buffalo to Chicago and Duluth will be awarded in eight distinct sections, and work must be begun by May 15, 1893, and completed within three seasons of 200 working days each, between May 15 and November 30. Congress has limited the cost of the channel to $3,340,000, of which $375,000 are now available.

The first section comprises the improvement of two shoals in St. Mary's River above the canal. The upper shoal lies northwesterly and the lower shoal northeasterly from the old Round Island lighthouse. The work to be done consists in excavating a channel within the side and end lines, the estimated excavation being 90,000 cubic yards.

The second section comprises the improvement of Little Mud Lake, between the lower end of Sugar Island and the lower end of the Dark Hole, St. Mary's River, the estimated excavation being 380,000 cubic yards.

The third section comprises the improvement of a reef abreast of Sarton Encampment Island, St. Mary's River, the estimated excavation being 90,366 cubic yards.

The fourth section comprises the improvement of a shoal about 1½ miles below Sarton's Encampment in Mud Lake, St. Mary's River, the estimated excavation being 67,100 cubic yards.

The fifth section comprises the improvement of a number of small shoals at the foot of Lake Huron, the estimated excavation being 256,000 cubic yards.

The sixth section comprises the improvement of the St. Clair Flats, the estimated excavation being 950,000 cubic yards.

The seventh section comprises the improvement of Grosse Point Flats, the estimated excavation for the width of 300 ft. being 120,000 cubic yards.

The eighth section comprises the improvement of the bar at the mouth of the Detroit River, the estimated excavation for the width of 300 ft. being 11,000 cubic yards.

IRRIGATION IN INDIA.

(Translated from *Mémoire* by Chief Engineer Barois, in *Les Annales des Ponts et Chaussées.*)

(*Continued from page 569, Volume LXVI.*)

RESERVOIRS.

IN many districts of India, and especially in the central and southern provinces, the reservoirs are the chief reliance for irrigation. This is the case not only in the dry season, when the flow of the streams becomes very small, but also in the rainy season, because the rains last but a short time and the water which falls flows away rapidly, although there are occasionally violent storms when the rainfall amounts to as much as 10 in. or 12 in. in 24 hours.

These regions have, from almost prehistoric times, been dotted with reservoirs of all sizes, which are fed by the rain falling on the neighboring slopes, by the smaller streams and by the rivers.

In the government of Madras there are between 50,000 and 60,000 of these reservoirs. The dykes or dams inclosing them have a total length of over 30,000 miles, and they have altogether some 300,000 works of masonry, small and large.

These reservoirs vary very much in size; many of them are of small extent, as may be seen by taking some districts of the province as examples.

In the Kistna District there are 657 reservoirs, of which 5 only supply water for irrigating over 1,000 acres each; 15 supply from 500 to 1,000 acres, while 384, or more than half, supply less than 50 acres each.

The North Arcot District has 3,297 reservoirs, of which 981 supply less than 10 acres each; 506 from 10 to 20 acres; 777 from 20 to 50 acres each, while 17 supply from 500 to 1,000 acres, and 4 only over 1,000 acres each.

In the South Arcot District, out of 3,495 reservoirs 1,970—much more than half—supply less than 50 acres each, while only 37 are large enough for the wants of over 500 acres.

The Madura District has no less than 13,291 reservoirs; but of these 48 only supply more than 1,000 acres each, while 12,580 furnish water for less than 200 acres, 1,116 supplying from 20 to 30 acres each; 2,073 from 10 to 20 acres each, and 5,518 less than 10 acres each.

The banks of the old reservoirs are built entirely of earth. Many of them are formed by dams closing narrow gorges, above which are found natural basins of greater or less extent. Thus the reservoir of Cammun, in the Guntoor District, which has an area of 10,000 acres, is formed by a dam 100 ft. high closing a ravine about 300 ft. across. The dam is of earth with slopes of about 1 to 2; the upper slope is covered with stone. This reservoir holds water enough to irrigate the district it serves for two seasons.

In the Mysore District the Nuggur Reservoir has a perimeter of 49 miles, but the dam is only 1,000 ft. long; this dam has a maximum height of 84 ft. and is 580 ft. through at the base. In the same district, on a branch of the Lokain River, there is another large reservoir with a dam closing a

defile only 225 ft. in width; the height of this dam is 125 ft., and it is about 400 ft. through at the base.

In many cases reservoirs are established on undulating plains, where the slope of the ground is from 1.5 to 2 ft. in 1,000. They are then formed by a dam crossing the plain at right angles to the general slope, and by two lateral dams or dykes running up the slope. Reservoirs of this class require a great length of dyke. They are placed as much as possible in situations where they do not depend entirely on the rainfall, and are most frequently supplied by a natural watercourse or a feeder canal from a river.

Some of these reservoirs, supplied by rivers or natural streams, are of great extent. The Chebranbankam Reservoir, near Madras, covers about 6,200 acres; it has a dam 3.4 miles long, which holds back a maximum of 20 ft. of water. The overflows have a total length of 650 ft.; the reservoir will hold nearly 2,960,000,000 cub. ft. of water, and will irrigate 10,000 acres of rice. The Veeranum Reservoir, in the South Arcot District, is fed by a canal from the Coleroon River; its dams are 12½ miles long and 20 ft. in maximum height. Its surface is 20,000 acres and its capacity is about 2,800,000,000 cub. ft. Red Hill Lake, which furnishes water to the city of Madras, is supplied by a special canal. It has a dam 3¾ miles long and 20 ft. high, a surface of 6,200 acres and a capacity of 27,000,000,000 cub. ft.; the overflows are 300 ft. in length.

In the Mysore District, where every drop of water is saved, we find a series of reservoirs arranged in *echelon* one above the other in the same valley; the reservoir below is placed at the point where irrigation from the next one above ceases.

The English engineers have not established new reservoirs in the presidency of Madras, but have only improved and developed the works which they found already in existence. They have taken care that the dams should be kept up to their normal height and profile, the overflows properly proportioned and solidly built, the feeder canals provided with suitable headworks; in short, that the system should work with the regularity and safety necessary to a successful system of irrigation.

The earth dams are generally built of material taken from pits near their sites. The earth is puddled or worked down simply by the feet of the men employed in their construction; but as the work generally requires at least two seasons, the rains of the monsoon assist. The inclination or slope varies from 2 to 3 of base to 1 of height; on the outer slope 1½ or 2 to 1 is generally sufficient. It is generally considered necessary to make the dam at high-water level as wide as the maximum depth of the water held back. It is recommended also, as a measure of security, that the dam should extend from 8 to 10 ft. above the highest water level.

The upper slopes of earth dams are generally protected by a covering of stone, clay or turf. The stone protection varies from 2 to 4 ft. in thickness; in some large reservoirs the stones are from 5 to 6 cub. ft., carefully placed with headers, or arranged in steps; in others the facing is simply riprap placed without special care.

The natives often consider it a sufficient protection to plant trees on the dykes.

In the small reservoirs they often use as facing fascines of rushes placed horizontally along the slope. After a short time these rushes take root and the slopes are soon covered with a thick vegetation. This system is so efficacious that along the rivers in the Tanjore Delta, where stone is not to be found, all the dykes are protected in this way.

Each reservoir is provided with one or more overflows. When these are not founded on rock or solid bottom, they are protected by stone facing having at least three or four times the width of the opening; this is at least equal to twice the height of the fall measured from the surface of the water to that of the base. The thickness of the stone depends on the fall; with a fall of 10 ft. and a depth of 3 ft. passing over the crest of the outflow the stone is at least 4 ft. thick.

The aqueducts taking water from the reservoirs are usually of masonry. They are often so arranged that they can be used to supply several canals at different levels.

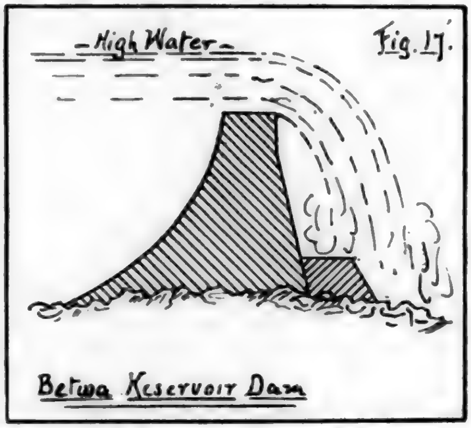
In Upper India there is less need of reservoirs, because the rivers there usually supply water throughout the year. There are, however, several in places where all the rain of the monsoon falls in a short time and where the surface is undulating in such a way that the water falling during heavy rains will flow off rapidly, producing only a very transient effect on the land. Reservoirs so placed which have had a very good result are those of Ajmere, of Cairwara and of Kaira. The last named holds about 330,000,000 cub. ft. of water.

In Central India there are many small dams on the less important rivers, the object of which is to maintain a certain reserve of water which will, by infiltration, feed the wells from which water is drawn for irrigation. The utility of these works is, however, not admitted by many experts. A dam of this class is that of Nya-Nagar, which is a masonry wall founded on a rocky bed. It is 312 ft. long, 10 ft. thick at the base and 7 ft. at the crown, and is 13 ft. high. It holds back the water in the stream for about 4,000 ft.

In the presidency of Bombay the English engineers have begun the construction of several fine irrigation reservoirs which deserve some special description.

1. *The Mutha Reservoir.*—This is on the Mutha, a tributary of the Kistna, about 10 miles from Poona. It is fed by the periodical rains which fall on the slopes of the Western Ghats and is intended to irrigate a very dry district on the great plain of the Deccan; it also furnishes water for the city of Poona and a number of villages.

This reservoir is formed by a wall of masonry founded on rock and having a length of 3,680 ft., not including an overflow 1,450 ft. long. The crest of the dam is 99 ft. above the river bed, and the overflow is 11 ft. below the crest, making the maximum depth of water in the reservoir 88 ft. The superficial area of the reservoir is 3,700 acres, and its total capacity is 5,152,500,000 cub. ft. of water.



2. *The Ekruk Reservoir.*—This work is in the same region as the Mutha Reservoir; it is on the Adhila River, 5 miles northeast of Sholapur. The dam is 7,200 ft. long; it is formed at the two ends by two masonry walls respectively 1,300 ft. and 1,400 ft. long, the central portion, 4,500 ft. long, being an earth dam, the maximum height of which above the river bed is 75 ft. This dam has a slope on the up-stream side of 1 in height to 3 of base, and of 1 to 2 on the lower side. On the up-stream side the slope is protected by riprap about 2 ft. thick. An overflow is made in the rock on each side, at each end of the dam, the total width of the openings being 370 ft.

The capacity of this reservoir is about 3,320,000,000 cub. ft. of water. Its superficial area is 4,000 acres. The watershed from which it is supplied covers about 90,000 acres. It supplies water to irrigate 21,500 acres of land through three canals located on different levels.

3. *The Betwa Reservoir.*—This reservoir is formed by a dam built across the valley of the River Betwa; the flow of the river in flood times rises to a maximum delivery of 700,000 cub. ft. per second.

This fine dam is founded on the rocky bed of the river,

and is built entirely of granite blocks with cement mortar. At the highest point the crest is 50 ft. above the river bed. The crest is 15 ft. in width. The front of the wall is vertical for a short distance and then has a batter of 24 in 100. The up-stream side has a curved profile. For a height of 50 ft. the wall is 61 ft. thick at the base.

A section of this dam at the highest point is shown in fig. 17. In front of the dam there is a counterfort of masonry, as shown in the section, placed there to protect the foundation against the wearing effect of the immense mass of water which falls over the dam in time of flood.

During the dry season water is taken from the reservoir by a canal; the head of this canal is provided with gates to regulate the flow. In the season of floods the water flows over the crest of the dam in a stream which is sometimes 18 ft. or 20 ft. deep.

This dam is one of the best of the new works constructed by the English engineers in India. It is at a point where an earth dam could not possibly stand, and where some means of retaining water for the dry season was necessary.

(TO BE CONTINUED.)

AREAL WORK OF THE GEOLOGICAL SURVEY.

(Condensed from paper by W. J. McGee, read before the American Institute of Mining Engineers.)

WHEN the United States Geological Survey began its work some 20 years ago, it was apparent that the first thing needed was the preparation of a topographical map. What was required was not a detailed map, but one giving the main landmarks and contour lines, and this has been carried out. At first scales of four miles, two miles and one mile to an inch were proposed for different sections, but finally a uniform scale of one mile to the inch was adopted, as the smallest meeting the requirements of geologists.

Up to the present time the area surveyed has been 537,000 square miles, distributed over 42 States and territories. The District of Columbia and four States—Connecticut, Massachusetts, New Jersey and Rhode Island *—have been completed. The maps are printed in sheets about 15 × 18 in., the side of each representing 15 minutes of latitude. The sheets are engraved on copper and printed from stone transfers, and it may be added that they are beautiful specimens of cartographic work. Each sheet is in three colors, the hydrography being given in blue, the altitudes between contour lines in brown and the topography in black. Surveys are completed for 694 sheets, of which 615 have been printed.

The law makes no provision for the sale of these maps, but it is expected that some arrangement will be authorized hereafter by which those who desire them can procure them at a fixed price.

Unfortunately the geologists of different countries have never agreed upon any uniform system of representing geological structure in maps, so that each country has adopted some plan of its own. The Geological Survey has adopted a system which has met with general approval thus far. This provides for the separation of rock formation into four classes, as follows:

1. Fossiliferous or Fragmental.
2. Volcanic.
3. Granitoidal and Schistoidal.
4. Superficial.

These classes of rocks are represented by ground colors and pattern overprints in such a way that the entire range of available colors may be used for each. The fragmental rocks are represented by the primary colors in orderly arrangement, each color indicating an age-group (Carboniferous, Silurian, etc.). These colors, used as uniform ground tints and overprints in line patterns, represent the distinct formations of which the group is made up. The volcanic rocks are represented by angular figures either on a white ground or over a ground tint representing an age-group. The crystalline rocks are similarly represented by hachures disposed either irregularly or in such a manner as to indicate structure. The superficial deposits are represented by round figures in such a manner that they may be mapped in their normal relation, overlying the older rocks, on the sheets showing the underlying formations.

The general system provides for the representation of the geology on the topographical maps. The atlas sheets are colored in manuscript by the geologists in the field and the geological symbols are afterward engraved on zinc. In order to make these sheets available for all uses, provision has been made for printing each sheet in portfolio form, supplemented by as many different impressions of the same map as may be required. Thus the portfolio will usually include a topographic sheet without geological symbols; a geological sheet showing only the age-groups and formations; a structure sheet in which sections drawn to scale are printed on a sheet showing the groups and formation boundaries; sometimes a sheet of columnar sections showing the structure in greater detail; in some cases a sheet showing the superficial deposits only; and, when the occasion requires, a sheet of mineral resources, showing the location of mines, quarries, coke ovens, smelters and furnaces, as well as mineral areas.

These geological surveys consume much time. Moreover, a variety of circumstances have combined to delay the completion of the surveys except in special districts, such as the Lake Superior iron region, the quicksilver and gold regions of California, the phosphate belt of Florida, the Eureka and Virginia City districts in Nevada, and some mining areas in Colorado.

Final geological surveys of greater or less extent have been executed in 32 States and territories. These surveys cover an area of 117,000 square miles, and are in part represented on 100 regular atlas sheets and a large number of special maps.

The cost of the topographical surveys has varied with the scale and other conditions from less than $1 to over $5 per square mile. The average cost of the survey, including drawing, has been $3 per square mile on the one-mile-to-the-inch scale, and the total cost since the first has been about $4 per square mile. The cost of the geological survey has varied between much wider limits. In fairly representative districts it has averaged $5 to $6 per square mile. The cost from the beginning has averaged $8 per square mile, but this includes preliminary expenditure on instruments, books, laboratories and similar matters.

* In Massachusetts and New Jersey the work has been done in co-operation with the State geological surveys.

CANALS IN INDIA.

(Condensed from the *Indian Engineer*.)

WE seem, if exchange goes on falling, likely for this cause alone to be soon entering upon a great canal-making era in Indian public works. For canals are the only class of large works (except planting State forests) which require but little imported plant. They can be carried out by excavation, stone-cutting and carpentry, as far as the bulk of the expenditure is concerned.

The disfavor attached to canals hitherto has been also in a great degree due to the attempts at combining the irrigation which involves a rapid current, with navigation requiring nearly still water. Then it was claimed for canals that they were better suited to India than trunk railroads, which few will be ready to admit.

Now that 16,000 miles of trunk railroad lines have been opened in this country, and silver is cheap in the West while it retains its former purchasing power in the East, the circumstances are totally changed; and canals are wanted, not in order to take the place of railroads, but to relieve them in some measure of their superabundant traffic.

There is, however, not the same field for canal as for railroad extension in India. The summit levels at which water to keep the canals full can be obtained in the interior are limited, and far apart. Then very little use can be made of the rivers themselves in navigation, on account of the strong current and considerable fall of their bed in most cases. They also run almost dry between rainy seasons.

This scarcity of water during the summer months necessitates the construction of one or more huge inland lakes, if canal communication is to be uninterrupted throughout the

year. There are favorable sites for lakes of this kind, particularly in the Mysore Ghat region; and examples are not wanting, in those long ago formed under native dynasties, at Jhansi, Hyderabad, Ajmere and other places.

Having fixed upon a choice out of the small number of summit levels available, laying down the canal routes on a map becomes an almost mechanical operation. Notwithstanding the many seeming difficulties, it would be quite practicable to lead a navigable canal—some 40 ft. wide and 5 ft. to 10 ft. deep—all the way from Allahabad, through the Rewah territory, and the heart of the Deccan, down to the Coromandel Coast; and then by a canal route already partially opened, right round Cape Comorin to the Bombay frontier in North Canara.

The highest summit level of such a canal, it is true, would be 1,500 ft. above the sea, and yet what at the first blush seems a troublesome obstacle may be shown, owing to the command of water-power it gives, a striking advantage.

By an adaptation of the trolley system used on electric railroads, the boats could be propelled by power furnished from turbines and dynamos at the locks. In many places locks could be replaced by inclines operated by water-power.

In designing canal systems for India there are one or two considerations to be kept in view. The evaporation is so great in a tropical climate that it is important to have depth rather than width. So that though 5 ft. of water would accommodate a fair amount of traffic, and it may be a long time before steam vessels are employed, the depth to be aimed at should not be less than 10 ft., either at once or by degrees.

Again cheap freight requires capacious boats, and they should therefore be of the largest size the locks will admit (or multiples of that size so as to go through in a batch).

There are no examples in India of either rivers or canals which have been able to compete with railroads.

We have said that irrigation ought not to be combined with navigation in an Indian canal; but some exception may be made. A current of a mile—and perhaps even up to two miles an hour—does not sensibly affect the speed of animal traction on a canal, so that a certain amount of water could be sold for irrigation.

As a precaution against famine in the Deccan, where rainfall is at intervals scanty and always light, the presence of a deep river-supplied navigable canal must prove a vast benefit. It would save the crops for miles on either side, and fill village wells.

Little has to be said about a system of canals for navigation in the plains watered by the Ganges and Indus. It is obvious that as they prove successful on a moderate scale further south, immense canals will be required following the course of, as well as branching off from, these rivers. Nor will it take long for the railroad managements to see that much of their bulky freight should go by canal rather than in expensively hauled trains; and then to bid to have the working of canal traffic, with the result of cheaper average freight rates for India all round.

WORKS ON THE GANGES CANAL.

(From *Indian Engineering.*)

The works at Myapore and Dhunowri are the most important of the drainage works on the Ganges Canal in the tract of country above Roorkee. Although they may be classed under the head of inlets as well as escapes for regulating the supply, they fall more appropriately under the head of dams and drainage works.

In fig. 1 we give a plan of the works which were originally constructed in connection with the departure of the Ganges Canal supply from the Ganges River and its branch at Myapore.

Myapore Regulating Bridge.

The Myapore Regulating Bridge—shown in the first of the large engravings—at the head of the Ganges Canal is the main connecting link between the towns of Hurdwar and Kunkhul, and the high road from Roorkee to Dehra passes over it. It was intended to serve the dual purpose of a public thoroughfare as well as the means for determining the amount of water passing into the canal, having a roadway of 39½ ft. in width.

The original Myapore headworks consisted of a brick regulator, with 10 bays of 20 ft. each, 16 ft. high, two wooden gates in each bay, inside the mouth of the canal, shown in our illustration. The river was governed by means of a weir 517 ft. in length. Its central escape, resting upon an 8-ft. floor of brick, over bowlder masonry 44 ft. wide, had 15 openings between brick piers, 3 ft. high and 10 ft. apart, fitted with drop gates and further raised by means of planks. The weir rose from the center to flank walls on each side 24 ft. in height, extending 800 ft. down stream, a lock-stand above the canal mouth running from it at an acute angle.

Fig. 1.

General Plan Myapore Head Works.

The second large engraving is a general view of the

Dhunowri works, which consist of a dam and inlet thrown across the Rutmoo torrent; a regulating bridge, and a bridge of cross communication in connection with the canal channel; and revetments with a variety of drainage works appended to them. These various details are shown in the site plan, fig. 2, which will lead to an easy understanding of the subject.

suit local requirements. These works are said to have cost nearly six lakhs of rupees.

It should be mentioned that the dam which appears in the illustration of the Dhunowri works shows a footway, which has now been superseded by a bridge. The box-work, filled with stones and held in position by piling, on the down-stream side of the dam has furnished the model for the crib-work weirs lately constructed in connection with the Irrigation Works of Upper Burma.

Dhunowri Works, Ganges Canal.

The Dhunowri works are situated about 13 miles below the head of the Ganges Canal, at its intersection with the Rutmoo River, which it meets on its own level, and the sills of the different works are therefore on the same level.

Our view shows the dam as originally constructed. It consists of 47 sluices of 10 ft. in width separated by piers 3½ ft. thick. These vents are flanked on each side by five sluices of the same width but having their sills raised 6 ft., the piers being of the same thickness as those of the center sluices. On the extreme flanks are platforms raised to a height of 10 ft. above the canal bed and corresponding in height with the rest of the piers. These elevated platforms, which are 17 ft. in length, are connected with the revetment by inclined planes. The revetment walls both on the right and left are of the same design, and, like the inlet, call for no remark. The bridge over the canal consists of three bays of 55 ft. each, 20 ft. in height from soffit of arch to floor of canal. The regulating bridge is almost identical with the Myapore Regulator, with minor modifications to

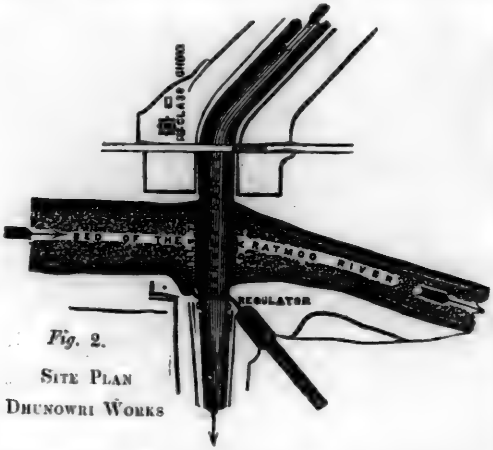


Fig. 2.

Site Plan

Dhunowri Works

TESTS OF METALLIC RAILROAD TIES.

An interesting note on a test of track laid on metallic ties has been made public by Herr Ast, Chief Engineer of the Kaiser Ferdinand Northern Railroad in Austria. In August, 1883, a trial section of 2 km. on the Vienna-Cracow line of this road was laid with Bessemer steel ties of the Heindl pattern, the rails—of the Vignoles or Stevens type, weighing 71 lbs. to the yard—being secured to the ties by clips and bolts. The corresponding section of the opposite track was at the same time laid with new oak ties treated by the chlorate of zinc process. The rails and rail-joints used were of the same pattern on both sections, and the traffic over each would, of course, be very nearly the same. The section is on a grade of 0.5 per cent.; part on a tangent and part on a curve of 4,350 ft. radius.

The arrangement of the ties on the two sections is very nearly alike, eight metal or eight wooden ties being used to a 22-ft. rail. Both kinds of ties are the same length, 8 ft.

From the time these sections were laid, in August, 1883, up to December 31, 1891, the number of trains passing over the section with metal ties was: Express passenger, 26,303; local passenger, 2,526; freight, 51,614; total, 80,443 trains. The average total weight of trains was 528 tons, and the total weight passing over the section was 42,480,000 tons.

It should be noted that one kilometer of the test section was ballasted with gravel and the other with broken stone, the stone being a hard limestone.

The results of this trial have proved altogether favorable to the metal ties. The rails have been kept in good alignment and level, and during the whole period there was no necessity for correcting the gauge. A careful account kept of all labor and material shows that the section on metal ties cost 14 per cent. less for maintenance than the corresponding section on wooden ties. The expense of the latter increased toward the end of the eight years, because some of the ties had to be replaced; and this expense, it is expected, will continue to increase for several years, as more new ties are needed.

After a service of nine years the metallic ties are, to all

appearances, perfect, and the engineer in charge cannot fix any time at which they will probably require renewal. The attachments of the rail are also in good condition, and the only material required for renewals has been a few bolts and nuts; even these were called for not on account of actual wear, but because of the misuse of tools by trackmen. The rails laid on these ties are in excellent condition, and show only the normal wear which might be expected from the loads they have carried. No rails were broken.

It is noted that the average annual expenses of maintenance of the kilometer ballasted with gravel were 4 per cent. less than those of the kilometer with broken stone. Other considerations also showed that with metallic ties the gravel ballast is much to be preferred.

There has been no complaint of lateral movement of the track, although many trains pass over it daily, including five fast express trains which sometimes attain a speed of 45 to 50 miles an hour.

The results obtained have been so satisfactory that the management of the road has decided to use these metallic ties for all renewals, and has already 364 km. of track laid upon them.

Results quite as good have been obtained with steel ties of the Heindl type on the Bavarian State Railroads, in a test extending over several years.

Herr Ast refers to the unfavorable results obtained on the Belgian State railroads with metallic ties of the Post and Braet types. He considers that the difference in results was not due to the form or material of the ties, for the material was the same, and the form does not greatly differ; nor to the strains thrown upon them, which do not pass the limit of elasticity, and which were really less on the Belgian lines than on the Kaiser Ferdinand Railroad. The difference in results he attributes entirely to the method of fastening the rails to the ties, which he considers imperfect in the Post and Braet systems, while in the Heindl tie the fastenings are so arranged as to properly support the rail, hold it in place and prevent too great strains on the bolts or undue wear and deformation of the holes in the ties.

These results seem to be the most favorable yet obtained in Europe with metallic ties; and the test seems to have been made with entire fairness and freedom from prejudice.

Fig. 1.

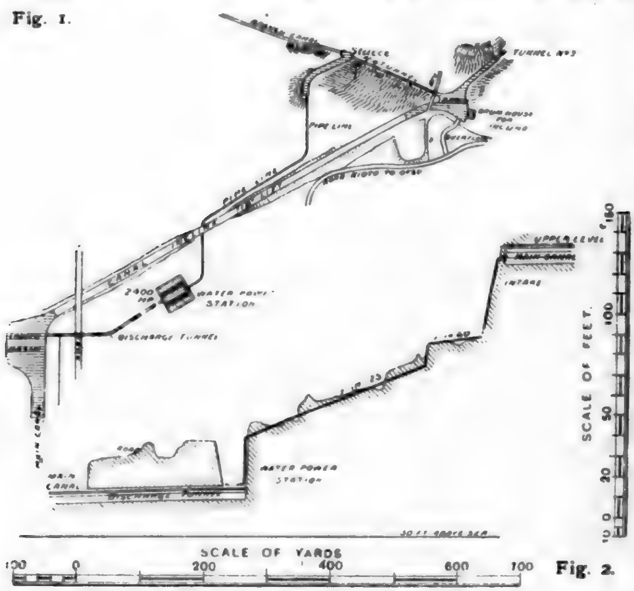


Fig. 2.

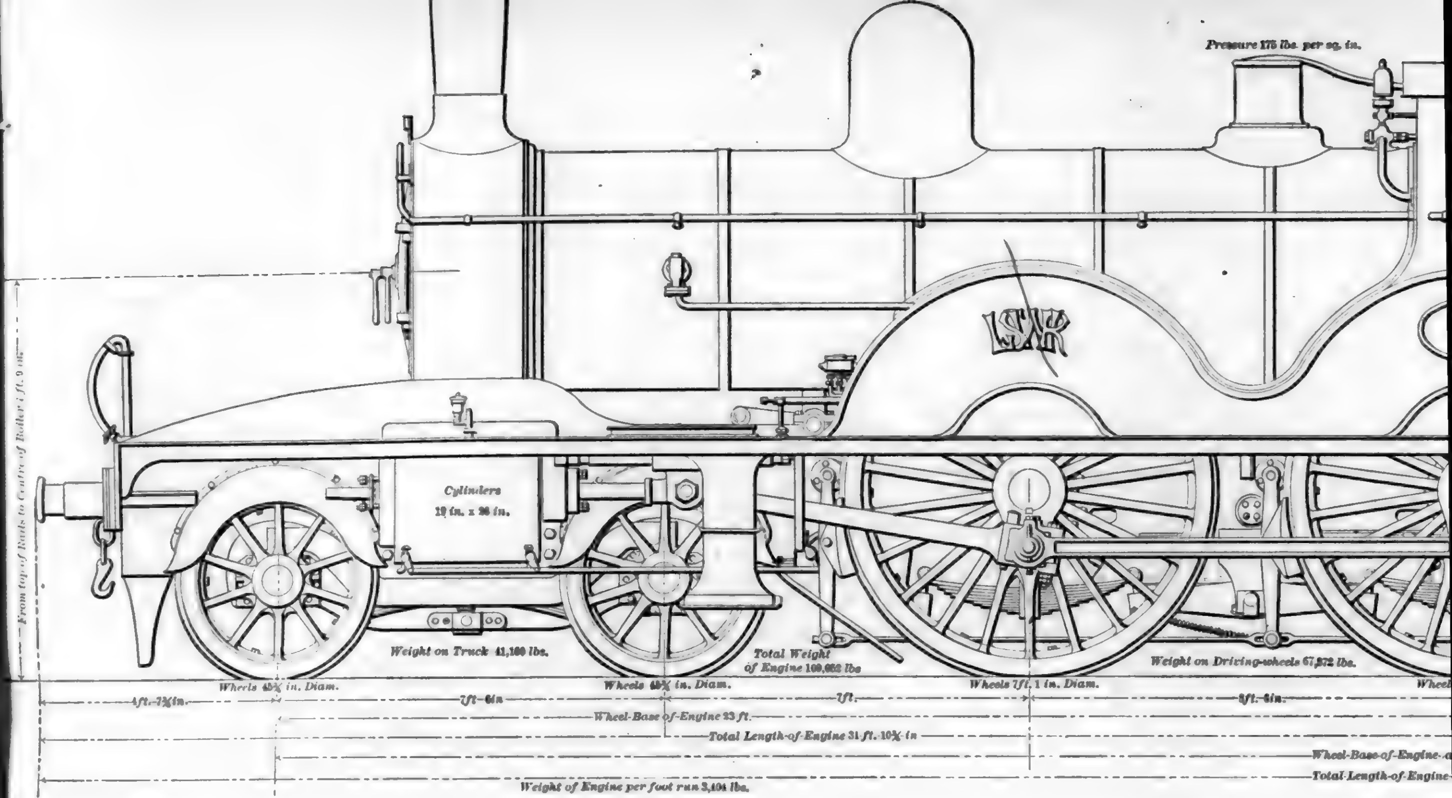
INCLINED PLANE ON THE BIWA CANAL IN JAPAN.

A JAPANESE CANAL.

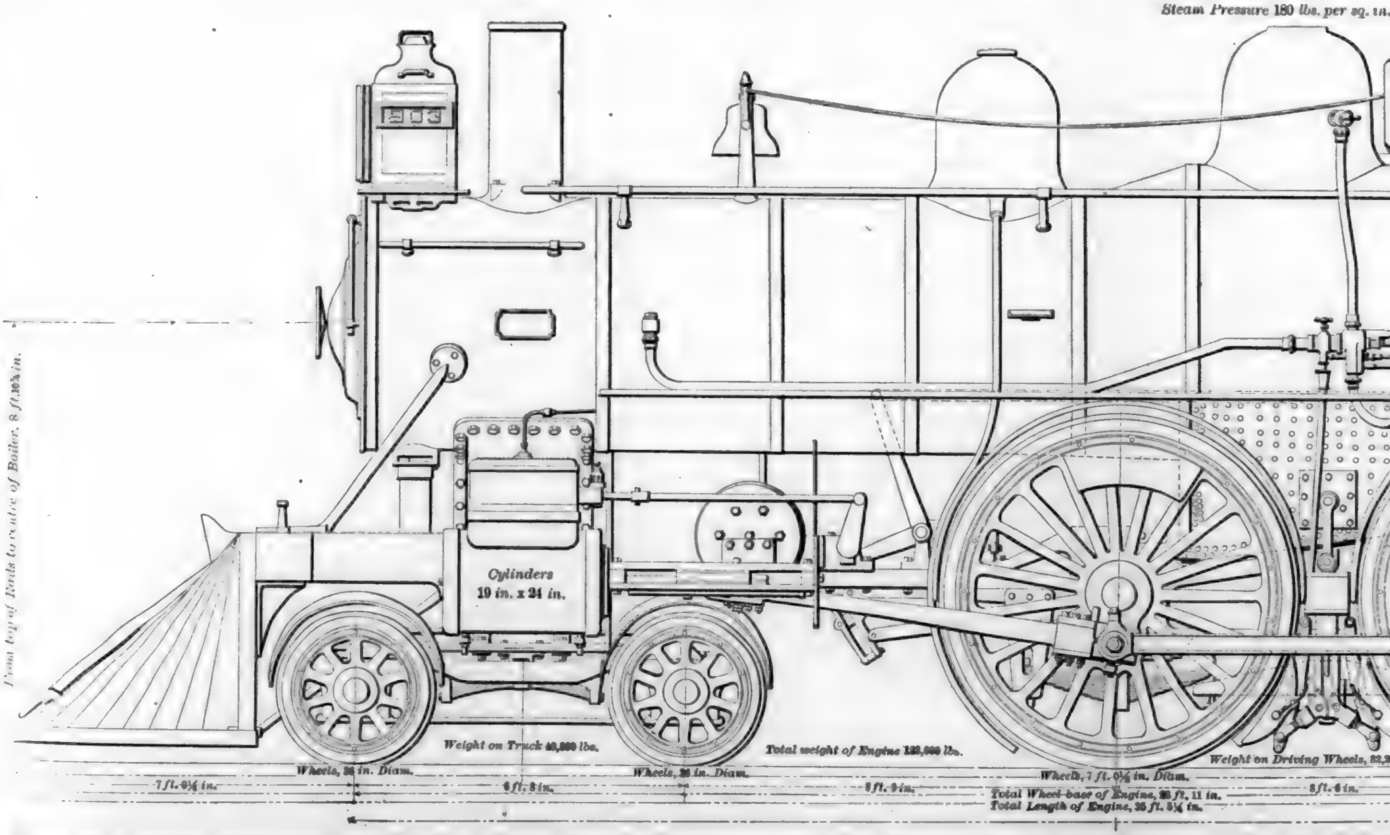
Some reference has heretofore been made to a canal recently completed in Japan, which extends from Lake Biwa to the city of Kioto. This canal is 6.9 miles long, and its construction has required some difficult work. It passes through three tunnels which are respectively 8,040 ft., 411 ft. and 2,802 ft. in length. Just below the third tunnel, at a distance of 5.3 miles from Lake Biwa, the canal is divided into two. One branch—the high-level—is used for irrigation purposes, while the other, which is designed for navigation, descends 118 ft. in a distance of 1,800 ft. to the level of the city, a slope of about 1 in 15. The boat traffic at this point is worked by an inclined plane-way, the boats being put into a wheeled cradle, which is hauled up and let down by means of a wire rope. In the illustrations—which are from *Industries*—fig. 1 is a plan and fig. 2 a profile of the incline. Fig. 3 is a view taken on the slope, showing the cradles in which boats are carried.

The cables of the inclined plane are operated by electric energy furnished by a Sprague motor driven by a Pelton water-wheel. The fall of the canal also affords a very valuable water-power, a part of which has already been utilized

BOAT INCLINE ON THE BIWA CANAL IN JAPAN.



Pressure 175 lbs. per sq. in.
LSWR
From top of Rails to Centre of Boiler
Cylinders
19 in. x 26 in.
Weight on Truck 41,180 lbs.
Total Weight
of Engine
Weight on Driving-wheels
Wheels in. Diam.
Wheels in. Diam.
Wheels 7 ft. 1 in. Diam.
7 ft.
8 ft. 6 in.
Wheel-Base of Engine 23 ft.
Total Length of Engine 31 ft. 10¾ in
Weight of Engine per foot run 3,404 lbs.

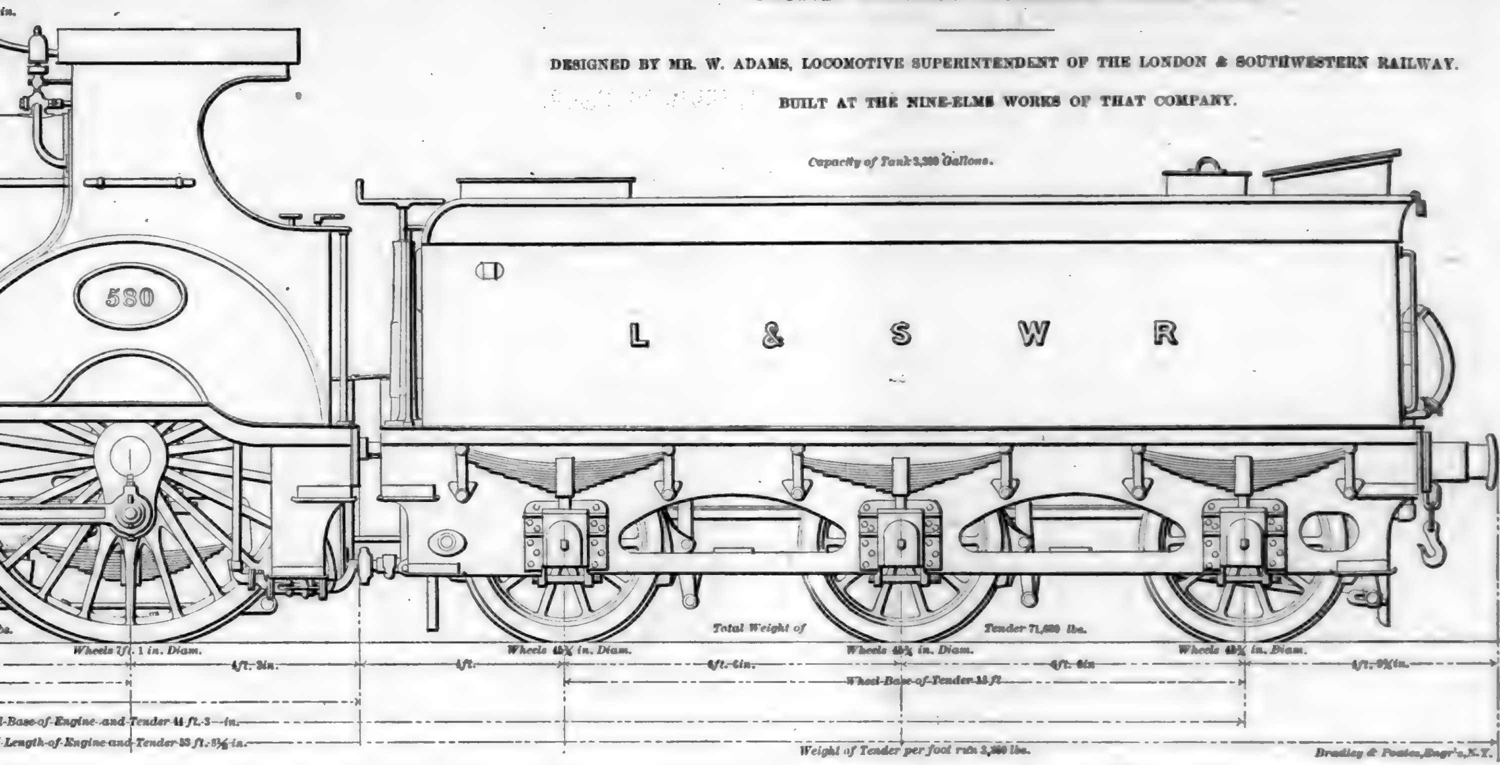


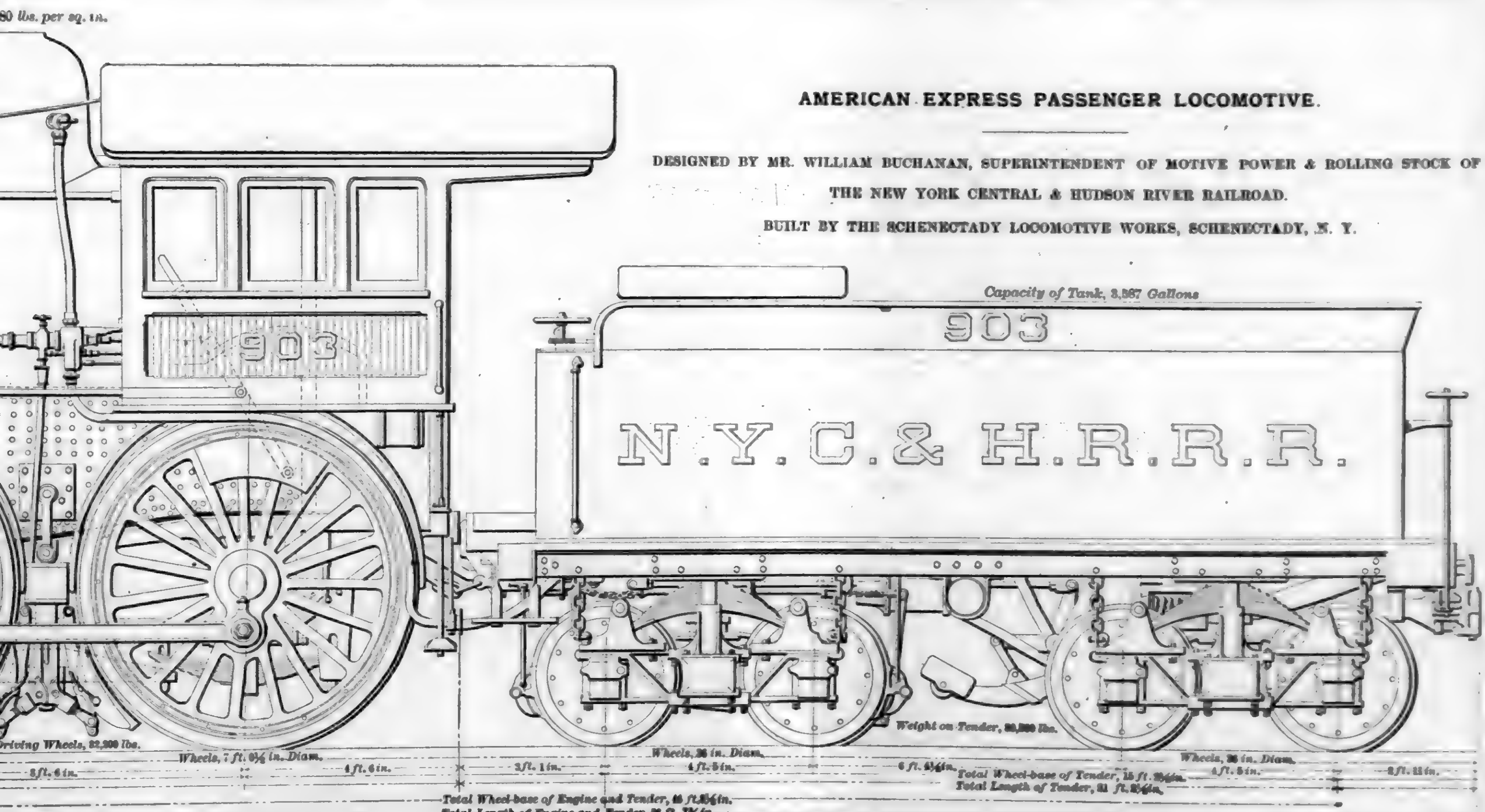
Steam Pressure 180 lbs. per sq. in.
From top of Rails to centre of Boiler. 8 ft. 10½ in.
Cylinders
19 in. x 24 in.
Weight on Truck
Total weight of Engine
Weight on Driving Wheels
Wheels, 36 in. Diam.
Wheels, 36 in. Diam.
7 ft. 0½ in.
8 ft. 6 in.
Total Wheel-base of Engine, 23 ft. 11 in.
Total Length of Engine, 35 ft. 5¼ in.

ENGLISH EXPRESS PASSENGER LOCOMOTIVE.

DESIGNED BY MR. W. ADAMS, LOCOMOTIVE SUPERINTENDENT OF THE LONDON & SOUTHWESTERN RAILWAY.

BUILT AT THE NINE-ELMS WORKS OF THAT COMPANY.





AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

DESIGNED BY MR. WILLIAM BUCHANAN, SUPERINTENDENT OF MOTIVE POWER & ROLLING STOCK OF THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

BUILT BY THE SCHENECTADY LOCOMOTIVE WORKS, SCHENECTADY, N. Y.

for various mechanical purposes by means of electric transmission. From figs. 1 and 2 it will be seen that the power station is located at the foot of the incline, water being supplied by three lines of 36-in. pipe, 1,300 ft. in length, delivering water to the wheels under a head of about 100 ft.

The canal extends 1.6 miles from the foot of the incline to the Kamaguwa River, with which it connects by a lock.

The canal has been built for a moderate sum, the whole cost not exceeding $1,250,000. The works were designed by Mr. Sakuro Tanabe, Professor of Civil Engineering in the Imperial University, and were executed under his supervision.

THE LOCOMOTIVE PROBLEM AGAIN.

In the Railroad and Engineering Journal for April last there was given the following

PROBLEM.

Let it be supposed that the stroke of the pistons of a locomotive is 2 ft., the diameter of the driving-wheels 7 ft. and the speed 60 miles per hour; what is the maximum and minimum velocity of the piston relatively to the earth, and not with regard to the locomotive, and when does each occur?

Several answers were received to this and were published in the July, August, October and November numbers of the Journal; since then an additional reply has been sent in, which is given below:

X.—BY PROFESSOR F. A. WEIHE, DELAWARE COLLEGE.

In solving this problem, the following assumptions have to be made: 1. That the speed of the locomotive is perfectly uniform. 2. That the cylinders are horizontal, and that a horizontal line passing through the axis of the cylinder passes also through the cross-head pin and the center of the wheel.

In fig. 8 let $A\ B$ represent the connecting-rod. The crank-pin will travel in the circle whose radius $= r = A\ O$ and

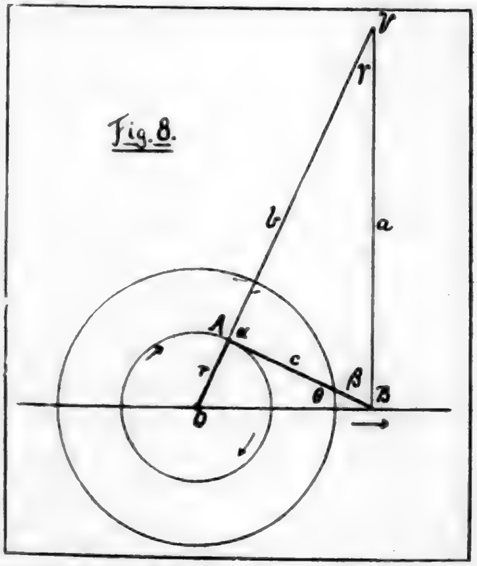


Fig. 8.

the cross-head pin B in the horizontal line $O\ B$. Find the virtual center V. The velocities of B and A will then be directly proportional to the virtual radii $V\ B\ (= a)$ and $V\ A\ (= b)$ respectively.

We have $\frac{a}{sin.\ \alpha} = \frac{b}{sin.\ \beta}$; $\therefore \frac{a}{b} = \frac{sin.\ \alpha}{sin.\ \beta}$. This will be a maximum when $d\left(\frac{a}{b}\right) = \frac{cos.\ \alpha}{cos.\ \beta} = 0$. This will be the case when $\alpha = 90°$. The velocity of B will therefore be greatest when the angle $O\ A\ B = 90°$. At this position

$$tang.\ \theta = \frac{r}{c} = cot.\ \beta = \frac{c}{b}.$$

Therefore $b = \frac{c^2}{r}$. Now

$$a^2 = b^2 + c^2 = \frac{c^4}{r^2} + c^2 = \frac{c^2}{r^2}(c^2 + r^2),$$

and

$$a = \frac{c}{r}\sqrt{c^2 + r^2}$$

$$\frac{a}{b} = \frac{\frac{c}{r}\sqrt{c^2 + r^2}}{\frac{c^2}{r}} = \frac{\sqrt{c^2 + r^2}}{c}.$$

By making $c = 3$ we have

$$\frac{a}{b} = \frac{\sqrt{10}}{3}, \text{ since } r = 1.$$
$$= 1.05409$$

Since the velocity of the locomotive is $= 1$ mile per minute, the crank will make $\frac{5280}{3.1416 \times 7} = 240.0970 +$ revolutions per minute, and the velocity of the crank-pin will be $= 240.0970 \times 3.1416 \times 2 = 1508.578$ ft. per minute.

The maximum velocity of the piston will therefore be $= 1508.578 \times 1.05409 = 1590.1770 +$ ft. per minute.

Since the velocity of the locomotive with respect to the earth is 5280 ft. per minute, and since the maximum velocity of the piston will occur twice in every complete revolution, once in the same direction as that of the locomotive and once in opposite direction, we will have for the maximum velocity of the piston with respect to the earth 5280 + 1590.1770 + ft. per minute, and for the minimum velocity 5280 — 1590.1770 + ft. per minute.

Expressing this in a ratio, we have

$$\frac{\text{Max. vel. of pist. (same direct. as locomotive)}}{\text{velocity of locomotive}} = \frac{5280 + 1590.1770}{5280} = 1.301 +$$

$$\frac{\text{Min. vel. of pist. (op. to direct. of locomotive)}}{\text{velocity of locomotive}} = \frac{5280 - 1590.1770}{5280} = 0.698 +$$

THE NEW MANNLICHER RIFLE.

An article in the London *Daily News* gives some interesting statements in relation to a new gun which has been devised by Herr von Mannlicher, the inventor of the repeating rifle which has been adopted by the Austrian and Italian armies.

There is nothing particularly striking in the outward appearance of the new automatic repeating rifle. It possesses the ordinary characteristics of the various repeating systems now in use. The beautifully-finished models shown, however, are somewhat shorter than the latter, their dimensions being about those of an ordinary carbine, and their length 40 in. The weight, so important a factor, is slightly under that of an ordinary repeating rifle. The bore is 6.5 millimeters in diameter, the same as that of the latest Mannlicher pattern adopted by the Roumanian and Italian governments. The rifle is a meter in length, while it is sighted up to 2,700 yards, and will carry a bullet 500 yards without loss of elevation; and its weight is less than an ordinary repeater.

The mechanism of the rifle consist of five essential parts, simple in detail and strongly made. First, there is the barrel containing the cartridge chamber; secondly, the locking lever, attached to the lower part of the barrel immediately underneath the cartridge chamber, and serving to engage and hold firm the third part—that is, the recoil and spring operated breech-bolt, when the cartridge is pushed home. The fourth part is the breech receiver, and lastly there is the trigger mechanism, which is so constructed that the shots may be fired in the most rapid succession or at any desired intervals. The mechanism, therefore, is simplicity itself.

With regard to the new weapon's performances, there was no space at disposal at the works for long-range firing. Descending into a big underground vault, bullets were fired,

or rather poured, into sandbags piled up against the base of a section of the huge fortification wall that was thrown round Vienna by Prince Eugene early in the eighteenth century. Herr von Mannlicher fired first, to show the handling of the rifle. The method of loading is the same as that practised with the ordinary Mannlicher repeater in Germany and Austria—the sure and practical clip containing five cartridges pressed downward into the magazine exposed to view when the breech-bolt is drawn back. A touch of the trigger of the automatic repeater, and the breech-bolt flies back upon its closed position.

Then followed five piercingly sharp explosions, and the empty clip dropped ringing from the magazine on the floor. The explosions seemed instantaneous. With a stop watch they were timed and found to occupy a *single second*. Barely 1½ seconds to come down from the "present" to the "ready" position, to insert another clip; and then five more shots banged forth in the same limit of time. There is no more recoil than in the case of a rook rifle. The mechanism seems to absorb the kick. The breech-bolt flies backward and forward at every discharge, ejecting the used-up smokeless powder cartridge, and pushing home a fresh one from the magazine. The eye cannot follow the movement, so instantaneous does it seem. And there is no escape of gas. In the hands of its inventor the rifle can discharge about 120 rounds per minute. The barrel becomes hot, but not so hot as to render the rifle useless for a time.

According to Herr von Mannlicher, his automatic rifle is not at the present time suited for general use by infantry, on account of the difficulties still encountered in supplying ammunition to the rank and file in the field in quantities sufficient to satisfy the demands of this cartridge-swallowing monster. It might, moreover, be a risky experiment to place in the hands of a soldier a rifle that can easily expend in one minute 100 rounds out of the supply of 150 that he carries in his cartridge pouches. Herein lies a serious difficulty, for every one knows how apt soldiers are to lose their heads and blaze away. On shipboard, however, when, for instance, sailors on an ironclad have to repel a torpedo-boat attack, the rifle would be extremely serviceable. The men could, with plenty of ammunition lying beside them, pour out bullets like a hailstorm. In such circumstances the fire from these rifles would be terrible, because after the first shot the aim need not be changed from the object first sighted at.

A PLAN FOR LOCOMOTIVE SHOPS.

At a meeting of the New York Railroad Club, held on October 27 last, Mr. M. N. Forney read a paper on a proposed plan for shops for building and repairing locomotives. A plan of the shops accompanied the paper, and is given in the accompanying illustration. The reasons for recommending the proposed plan is given in the paper as below.

The following seem to be the principal considerations which should govern the arrangement of shops in relation to each other.

1. Facility in moving material to and from them.
2. Facility of access from one shop to another. This should be in proportion to the amount of intercourse between them.
3. Materials should always be moved in the direction of their destination, and not backward and forward over the same route.
4. Safety from fire.
5. Facility of supervision.
6. Amount of railroad track required.
7. Facility of drainage.

These considerations will be taken up in the order in which they are named.

One of the chief problems of transportation in locomotive shops is how to move boilers, locomotives partly or completely finished, tenders, trucks and wheels from one shop to another, or from one part of a shop to another part. To do this a transfer table is usually employed. The impression is very general that such a table affords the most satisfactory means of transferring boilers, locomotives, etc., from one shop or part of shop to another. As there are some very grave objections to transfer-tables, and as locomotives and their parts may be handled with equal or greater facility with other means, some consideration will be given to the subject here.

Under any and all circumstances a transfer-table is the cause of a great deal of inconvenience. A pit of greater or lesser extent is required. This is an obstacle in the way of communication from one side to another. A wheelbarrow cannot be wheeled across it, nor a wagon and horse driven over it excepting on the table, which can only be at one place at a time. Walking across the pit is uncomfortable, especially when the hinges of the knee lack the lubrication of youth. Unless thoroughly drained, water accumulates in the pit when it rains, and it is filled with snow in winter, and is a receptacle of rubbish at all times and, excepting for the one purpose which it is intended to serve, it is a perpetual obstruction to free intercourse between some of the shops, and a nuisance generally. Happily, since the introduction of traveling cranes transfer-tables are not essential, if there is room enough to lay out the shops as may be desired. Boilers and engines can be moved inside the erecting shops with equal or greater facility with such cranes than they can be with the aid of a transfer-table, with the added advantage that a great deal of work can be done or facilitated by traveling cranes which cannot be done by a transfer-table.

If three tracks are arranged longitudinally in the erecting shop, with pits below the two outside tracks only, and the middle one is kept clear, the movement of the boiler and engines, and the handling of their parts by the traveling crane are very much facilitated.

By connecting the middle track with a turn-table outside of the shops, and then arranging the other buildings so that each of them may be connected with the turn-table, the transfer-table, with all its inconveniences, may be dispensed with.

Such an arrangement is shown in the plan herewith. In this the buildings are grouped around a central turn-table, which is connected directly with each of the shops, excepting the smith-shop and foundry, by a separate track.

The materials for the smith shop and foundry are delivered from side tracks connected with the main line as shown.

Besides those already mentioned, a transfer-table has the added disadvantage that separate power, either electric or steam, and an attendant are required to run it, whereas a turn-table does not require either power or attendant, excepting the person or persons who use it. A turn-table can be used at all times, either Sundays or holidays or nights, whereas a transfer-table requires either steam power or electricity to run it.

With reference to the cost of the two systems, it may be said that a 60-ft. turn-table without track, pit or masonry, will cost $1,500. The carriage for a 40-ft. transfer-table will cost $1,200, but the track, pit and masonry for the transfer-table will cost considerably more than the corresponding portions of a turn-table, so that of the two the turn-table will be the cheaper.

With reference to traveling cranes it may be said that probably no one acquainted with the uses of these appliances would recommend building an erecting shop without one or more of them, if it is intended to do work in it in the most expeditious way and at the lowest total cost, counting interest and all other charges. To serve their purpose fully, cranes must be made capable of lifting engines so as to put their wheels under them. If transverse tracks are used, engines must be lifted with one crane whose girder is parallel to the tracks and travels crosswise to them, and it must have two trolleys and a capacity equal to or exceeding the weights of the heaviest engines to be lifted. If the tracks are longitudinal the cranes extend across the track and travel parallel to them, and two cranes, each with one trolley and a capacity equal to half the weight of the heaviest engine, are required to lift it. As the concentrated weight of a single crane is greater than that of the two cranes, the structure on which the latter run may be lighter than is required for the single crane, so that probably the total cost of two light cranes and their supporting structures will be little if any greater than that of the single crane.

The use of two cranes has also the advantage that when not employed in lifting engines they can each be used simul-

taneously in doing other work in different parts of the shop, whereas one crane can be used at one place only.

It will also be shown further on that if the machine shops and machinery are arranged as contemplated in this paper, the cranes in the erecting shops can also be used for serving some if not all of the heavy machine tools.

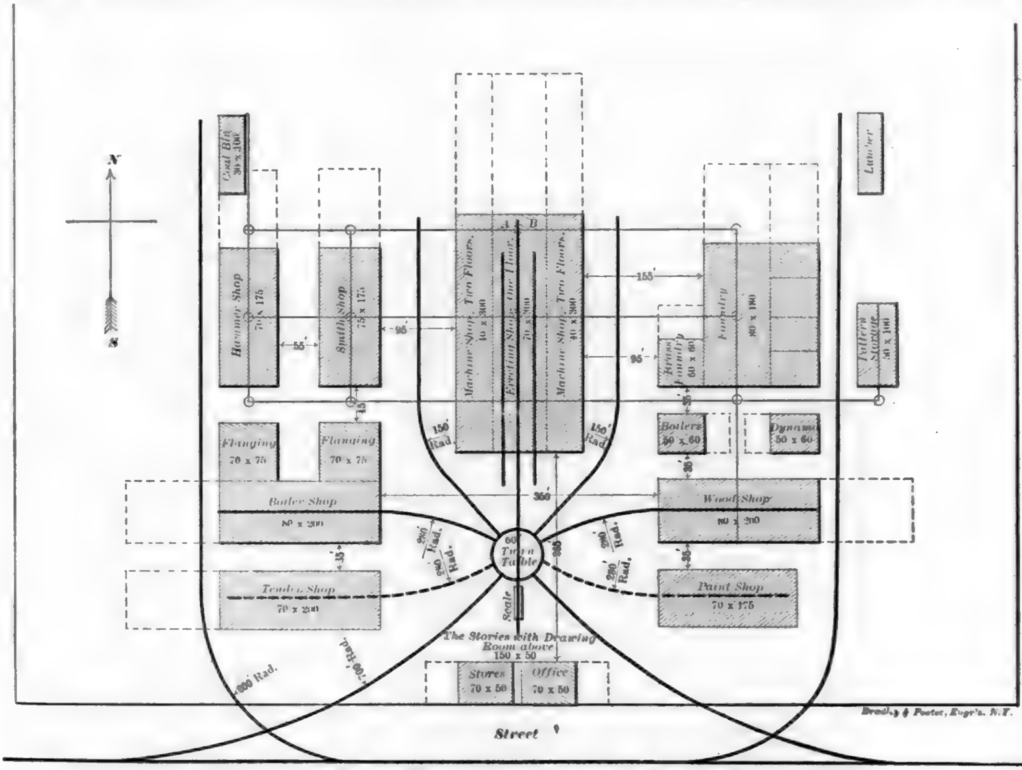
It has been suggested that a single light crane may be used for handling the parts of locomotives in an erecting shop with transverse tracks. It is doubtful whether any one who has ever seen the facility with which locomotives can be handled with cranes in an erecting shop would propose the use of appliances of that kind which would be too light to lift the heaviest locomotive. It is safe to say that the time required to do work with cranes would be counted by minutes, whereas if done without cranes it would be counted by hours.

The work done and the labor saved by the use of cranes in erecting shops is not, however, confined to lifting engines and boilers. In practice in shops equipped with these appliances every piece too heavy for a man to lift is handled with cranes, with a great saving of labor and time. As evidence of this, I submit the following letter from Mr. Joel West, Master Mechanic of the West Burlington shops of the Chicago, Burlington & Quincy Railroad, which are provided with cranes:

"Dear Sir: Some of the advantages of an erecting shop constructed with overhead cranes and longitudinal tracks in place of transverse pits, in my mind are as follows:

"All the material for the erecting of an engine can be brought from the finishing shops on rubble cars over small turn-tables and delivered at either end of the erecting shop, and the rubble car with its load can be picked up and taken to the point where the engine is to be erected, and each part can be handled from the rubble car directly on the engine; the engine frames and cylinders can be all bolted up and the boilers brought in in the same way from the boiler shop, and carried and dropped in its place after the frames and cylinders are all ready for the boiler, and all parts of the engine can be put into their places and the engine picked up as a whole, carried and set down at either end of the shop with water and steam put into the engine from a battery of stationary boilers, so that the engine is ready to go when she is set down at the door. If desired, as the engine progresses in her construction, she can be picked up in any stage of the erection and carried to any other part of the shop for the different men that are erecting the different parts. This avoids all outside transfer pits, which are very expensive in this country, from being blocked with snow, and put all the transfer work inside of the shop, where it is comfortable in all kinds of weather for men to work. It avoids a great many expensive side doors in a shop; makes a shop much warmer in winter and gives room where these doors would be located for work benches, heating apparatus, etc. I consider an overhead crane an indispensable necessity for handling all heavy parts of an engine. Two men can handle the cylinders, frames, decks, boilers, cabs, sand-boxes, dome casing, smoke-stack and the like, and put them in their places with all ease. In our shops we do not use jack-screws of any kind; an overhead crane is also an indispensable article in a tank shop, frame shop, as well as in a truck shop. It saves a great many tracks, as trucks can as well be put on a floor as anywhere else, and when completed can be carried to any track where they are wanted. Overhead cranes can be used in any part of the shop, while all such arrangements as drop pits can only be used for a small proportion of the work, while an overhead crane can be used for the largest or the smallest, and is not in the way of any one.

"I think that any one that sees the workings of an overhead crane in an erecting shop would not build a shop in any other way."



PLAN FOR LOCOMOTIVE BUILDING SHOPS.

If it is contemplated to do repairs as well as new work in

shops, such cranes will be especially useful, because in doing repair work locomotives must be taken off as well as put on their wheels, and the different parts must be taken down as well as put up.

Testimony to show the economy of time and labor in erecting locomotives by means of traveling cranes might be extended almost indefinitely. After diligent inquiry the writer has failed to find any one who has had experience in their use who has not been an earnest advocate of them.

The opponents of the system, as far as the writer's experience goes, are found only among those who have no practical knowledge of its advantages.

It may be added that, so far as convenience or facility of doing work is concerned, other things being equal, it makes no difference whether erecting tracks are longitudinal or transverse.

As already explained, the erecting shops should be provided with three tracks from 20 to 24 ft. apart between centers and with about 10 to 12 ft. clear from centers of outside tracks to the supporting posts of the traveling cranes. The two outer tracks should have pits, but the middle one should be without. The work of erecting is done in the outer tracks alone, the inner one being kept clear for the movement of material either with the cranes or by trucks.

These reasons have led to the recommendation of an erecting shop with longitudinal instead of transverse tracks, and an arrangement of shops whose tracks communicate with each other by means of a central turn-table, as shown in the plan herewith.

With the space specified between tracks the width of such an erecting shop will be from 60 to 72 ft. clear inside. The width given in the plan is 70 ft. to the outside of crane-posts.

There should be room for six engines on the erecting tracks, and not less than 40 ft. length of track should be allotted to each engine. Those on each side track would occupy 120 ft. of the length of the shop, and if room is given on those tracks for repairing the same number of engines at the same time, 240 ft. in length of shop would be required.

The erecting shop represented in the plan is 300 ft. long. This not only gives standing room for 12 engines in the erecting tracks, but leaves 50 or 60 ft. of the length of the shop in which it is proposed to locate some of the heavy tools at *A* and *B*. The floor area of the shop is greater than the calculations show will be needed, but the additional room is provided to give space for doing repair work.

The second and third considerations which should govern the arrangement of shops—that is, facility of intercourse between them and the movement of materials, will be considered together.

As most of the finished work must be taken directly from the machine shops to the erecting shops, these buildings should be adjoining each other. If traveling cranes are used in the erecting shop, its height must be equal to about two stories of an ordinary shop. With the use of elevators work can now be moved vertically as cheaply as it can be carried horizontally. Therefore the machine shops are placed alongside of the erecting shop, and if its sides are not enclosed by walls but only by posts to carry the structure and the traveling cranes, the machine shops may be arranged on each side of the erecting shop in the form of bays in the ground floor, and of galleries above the bays, as shown in the plan. This gives the greatest possible facility of intercourse between the machine shops and the erecting shops.

Suitable elevators must be provided for raising and lowering the work to or from the galleries. The floors of the galleries are supported from the roof, which leaves the lower floor clear of obstructions.

The heaviest tools may be located at *A* and *B* in the north end of the erecting shop, as indicated in the plan. In these two positions they can be served by the traveling cranes in the erecting shop. Balconies, either movable or fixed, may project from the galleries to receive work which is handled by the cranes.

The smith shop, it will be seen, is located on one side of the erecting and machine shops, and the foundry on the other. The distance—95 ft.—between the machine shops may be greater than is required, but can be reduced when the buildings are laid out on the ground. If it is reduced, the radii of the curves leading from the several shops to the turn-table must be made shorter.

With this arrangement work from the smith shop would be taken direct to the machine shop next to the smith shop, and castings from the foundry would be taken to the shop adjoining it. Naturally the heavy tools to do wrought-iron work would be placed next to the smith shop and those for cast-iron work will be next to the foundry.

The arrangement of the other shops is shown clearly in the plan. They are all grouped around the center turn-table, as shown, and all of them, excepting the smith shop and foundry, are connected with it. By this means work can be transported from any one shop to any other, and by a very direct route.

The office commands a view of all the shops excepting the hammer shop. This facility of observation from the office is regarded as a matter of some importance.

With this arrangement proposed, work will always be moved toward its destination, and material can conveniently be delivered at any required point.

The buildings are all more than 30 ft. apart. No reduction in insurance can be obtained by locating them further apart.

The amount of track required outside of the buildings is about 2,900 ft., and only three switches are needed to connect the branches with the main track. The drainage can all be conducted to a central drain running either north and south or east and west.

The total floor area of the buildings is as follows:

	Sq. ft.
Erecting shops, 70 × 300	21,000
Two machine shops, 2 floors each, 40 × 300	48,000
Foundry, 80 × 180	14,400
Cupola, sand-house, etc., 60 × 180	10,800
Brass foundry, 60 × 60	3,600
Boiler shop, 80 × 200, two wings 70 × 75	26,500
Smith shop, 75 × 175	13,125
Hammer shop, 70 × 175	12,250
Boiler house, 50 × 60	3,000
Dynamo house, 50 × 60	3,000
Wood shop, 80 × 200	16,000
Pattern storage, 50 × 100	5,000
Office, two floors, 150 × 50	7,500
Total	184,175

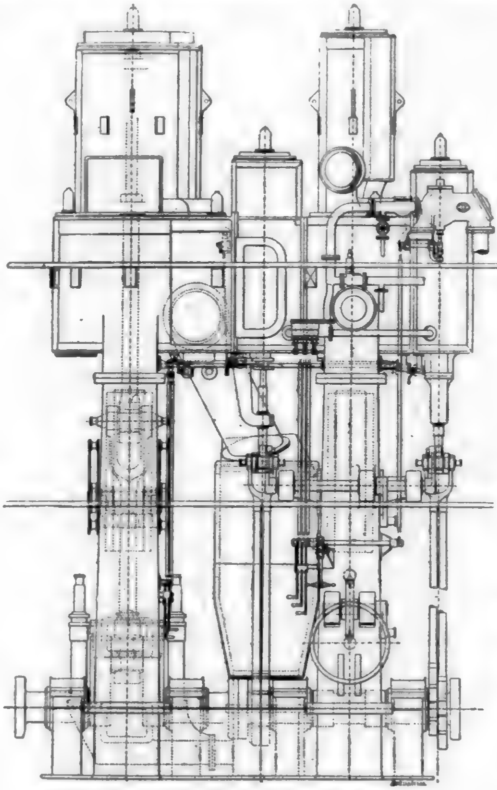
In addition to these, a tender shop, 80 × 200, and a paint shop 70 × 175 are proposed. These may not be needed when works are first started. They will give an additional area of 28,250 ft., making the total of 212,425 sq. ft. The two shops last named are shown on the plan.

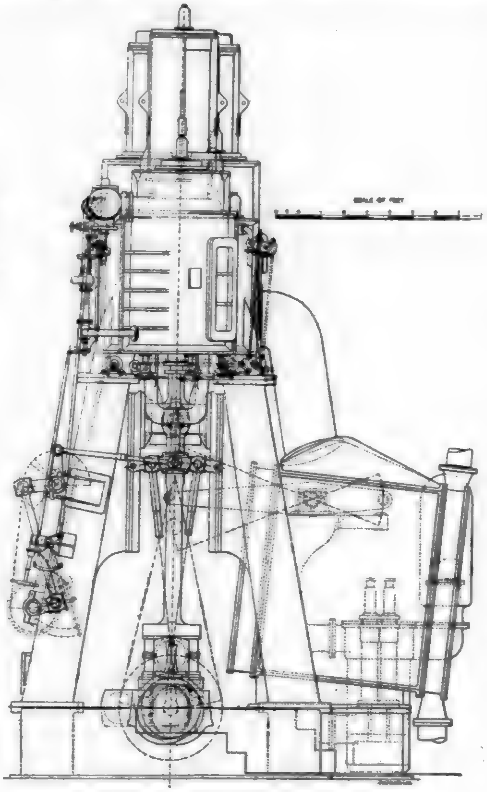
A QUADRUPLE-EXPANSION MARINE ENGINE.

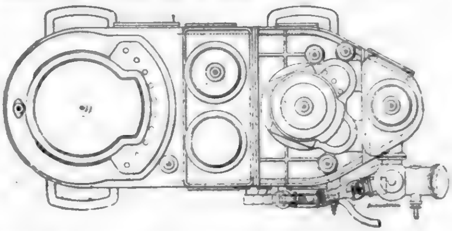
The accompanying illustrations, from *Industries*, show a quadruple-expansion engine altered from an old compound engine in the works of Denny & Company, at Dumbarton, Scotland. The new engine is of a type designed by Mr. Walter Brock, having two cranks only, the high-pressure cylinder being placed above the first intermediate and the second intermediate above the low-pressure cylinder. In this design the lower or front heads of the two upper cylinders form the covers for the two lower ones, there is no stuffing-box exposed between the top and bottom cylinders, and no alteration to any of the original valve or other gear is required. Neither are the number of stuffing-boxes and glands increased after the transformation is complete, as the valves for the four cylinders are all situated in the casings of the two lower cylinders.

The engines shown were built for the steamship *Duke of Westminster*, now running in a line owned by the New Zealand Shipping Company. The vessel was built in 1882, is 400 ft. long, 40.3 ft. beam and 28.7 ft. depth of hold.

The old engine was of the ordinary compound surface-condensing type, with cylinders 48 in. and 86 in. × 54 in. stroke. Steam was supplied by three double-ended boilers working at a pressure of 75 lbs. As altered there are two double-ended boilers, working at 160 lbs. pressure; they are fitted with the Howden forced-draft apparatus, and







QUADRUPLE-EXPANSION MARINE ENGINE.

BY DENNY & COMPANY, DUMBARTON, SCOTLAND.

supply steam for two engines running the refrigerating machinery of the ship, as well as for the engine described. The cylinders of the new engines are 25½ in., 38 in., 51 in. and 73 in. × 54 in. stroke; the ratios of the high-pressure cylinder to the others are thus 1 : 2.22 ; 1 : 4.00 and 1 : 8.20.

On the trial trip after the new engines were completed the mean speed was 13¼ knots an hour in a run of several hours. The power developed by the engines, as computed from diagrams taken while running at the speed named, was: First cylinder, 636; second, 599; third, 596; fourth, 732; total, 2,563 H.P. This is an increase of about 40 per cent. over the old compound engine.

The ship is a freight carrier, not built for speed, but since the change of engines has made one trip in which she showed a greatly improved performance, with a saving in fuel.

Denny & Company have built a considerable number of quadruple-expansion engines of the same general type.

COLUMBIAN EXPOSITION NOTES.

The great transfer table, which is to be used in running the locomotives and coaches of the transportation exhibit on to their respective tracks, is now completed. It is about 70 ft. in length, and will travel on seven pairs of wheels. The tracks upon which it will ply are situated about 2 ft. lower than the tracks to be occupied by the exhibits. This allows the track on the surface of the transfer table to come on a level with those on which the exhibits are to be shunted.

Extending about three-fourths of the length of the transportation annex is a cut in the flooring about 2 ft. in depth and 70 ft. in width. Seven rails are laid its entire length, and it is on these that the transfer table will travel.

The table will have a carrying capacity of 100 tons. It will be operated by electricity, and one man will have complete control of it. According to the amount of weight on it the table can be made to travel back and forth at a speed varying from 120 ft. to 225 ft. per minute.

A dynamo of 30 H.P. operates the machinery. The dynamo and gearing are on a small platform attached to the car at its center. The electricity operating the dynamo is carried to it through two protected wires placed within a few inches of the ground on which the traveling table rails are laid. The dynamo is of the Thomson-Houston make, and the method by which the electricity is carried to it by the wires is known as the double trolley system. The electricity will go around the circuit of the wires and back to where it is generated. The rails will, therefore, not require to act as return circuits for the electric fluid as in the street

car electric systems. The car is designed by W. L. Clements, Mechanical Engineer of the Industrial Works, Bay City, Mich., which is furnishing the apparatus.

The manner of shifting the locomotives, coaches, cars, wagons, etc., from the track on which they come into the yard to the one on which they are to be placed on exhibition is a very simple one. The table is run down along its bed until its surface tracks are even with those from which the exhibit is to be removed. In the machinery of the motor is a revolving drum and small, but strong, steel cable. The cable is attached to the locomotive, or whatever the exhibit is, to be drawn on. By pulling down on a small lever the man operating the motor sets the drum revolving. The cable is wound up and the locomotive drawn on the tracks. Then the gearing is started and the table placed opposite the track intended for the exhibit. By running the cable of the drum around a post the locomotive is drawn off in much the same way that it was drawn on.

The pumping machinery for the Fair grounds is now being put in place in the building constructed for it at the northeastern end of Machinery Hall. Altogether, the apparatus in this building will have a pumping capacity of 40,000,000 galls. of water every 24 hours.

The machinery is from the works of Henry R. Worthington, New York. There are four different types of engines to be employed. One of these, a horizontal, high-duty, duplex engine with a capacity for supplying 12,500,000 galls. of water daily, is almost ready for work. It is identical with one now in use in the city of Lowell, Mass.

Its two low-pressure cylinders are 50 in. in diameter and have a piston stroke of 28 in.; length of plunger, 27½ in. The high-pressure cylinders, of which there are also two, are 25 in. in diameter. The air chamber stands 6 ft. 6 in. in height and has a diameter of 40 in. The air in this chamber is used for feeding the compensating cylinders, which act as fly-wheels do on engines. The pumping works to be used at the World's Fair grounds occupy comparatively little space for the capacity they are to develop.

The bed-plate of a vertical duplex engine has just been put in position. It weighs 40,000 lbs. and will support the water and the steam cylinders and all the machinery necessary to pump 15,000,000 galls. of water daily. The entire height of this will be 49 ft. 2½ in. Of this 10 ft. will be below the floor proper.

The suction pipes of both engines are 30 in. in diameter and the delivery pipes into which the water is forced from all the four engines are 46 in. in diameter. In the center of the building is a well about 18 ft. in diameter from which the suction pipes draw the water. The well is connected by a tunnel with the main lagoon, and the water is to be used in the fountains, etc.

The two other engines of the pumping station are a triple-expansion vertical condensing engine and a high-speed engine with a capacity of 5,000,000 galls. a day.

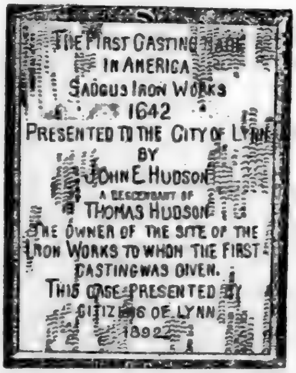
A recent Washington dispatch says that it is the intention of the Geological Survey in its exhibit at the World's Fair to elucidate the geology of the United States, which will represent its work in both the field and the office. Mineralogy in the United States will be shown as perfectly as possible, mainly by selected specimens, and not a large mass of material from any of the localities. Rocks of the United States will be shown as an educational collection. There will be displayed cases of American fossils, so arranged as to show both their distribution in the United States and their order of geological column. In connection with these will be included restorations of some of the enormous fossil animals discovered by Professor Marsh. Office work of the Survey will be illustrated very largely by photographs, photographic transparencies, maps and drawings. With these will be displayed the instruments used in the work of the Survey, together with a series of enlarged relief maps, constructed to show the geology and topography of the country. In addition to the collections having a purely scientific value, a collection will be prepared to show, by direct association of specimens, descriptive labels and maps, the economic resources of the United States, including ores and other minerals of commercial value, arranged so as to illustrate at a glance the wealth of the United States as regards each particular class of objects.

THE FIRST IRON WORKS IN AMERICA.

An interesting relic, which was for many years carefully preserved, was recently presented to the city of Lynn, Mass., by Mr. John E. Hudson, a descendant of the original owner. This relic, which is well authenticated, is believed to be the first casting made in America, and is shown in the accom-

THE FIRST IRON CASTING MADE IN AMERICA.

panying engraving, made from a photograph of the original. It is a kettle, weighing 2 lbs. 4 oz. and holding about a quart, and the somewhat rough workmanship of the moulders of that day is well brought out in the photograph. It will be carefully preserved, and is placed in the Lynn city hall in a case, the back of which is formed by an iron tablet



bearing an inscription, which is shown in the second illustration. This tablet illustrates the skill of the iron founders of to-day, and is used just as it came from the foundry, untouched by tools; it has been treated by the magnetic oxide process to guard against corrosion. The groundwork

is a woven bamboo pattern upon which the letters of the inscription appear.

The formal presentation to the city was made November 22, when Mr. Hudson made a brief address, to which Mayor Hayes responded. Mr. C. J. H. Woodbury, of Boston, then made a very interesting historical address, giving an account of the first beginning of iron working in America, of which this relic is a memorial. This was made about 1642 at the Saugus Iron Works near Lynn, where a blast furnace was established to work the bog ore found in the meadows along the Saugus River. To this was added later a forge or bloomary for making wrought iron from the pig iron of the blast furnace, and it is known that steel was also made there. A machine shop afterward formed part of the works. The head and manager was Joseph Jenks, who seems to have been an accomplished workman and a man of much ingenuity. He built the first fire-engines used in Boston, he invented a saw-mill and a new form of water-wheel, and to him is due the form of scythe now universally used—long and narrow, stiffened by a ridge along the back—which speedily replaced the broad, short bushwack scythe previously in use.

Water-power was used to run the works, where cannon were cast at one time, and a fairly prosperous business was done. In the blast furnace charcoal was used as fuel, and lime obtained from oyster-shells as a flux. Some prominent persons in the colony were interested in the works from time to time, and they are frequently mentioned in the old records. They were undoubtedly of great use in gathering and educating skilled mechanics, and in showing the possibility of making iron in the new country.

The works were in operation over 45 years, and seem to have been closed about 1688, when it is probable that the supply of bog ore accessible was nearly exhausted.

It seems to be historically established that the Saugus Iron Works were the first in America to go into successful operation. Iron ore was mined by the colonists in Virginia at an early date, and an attempt was made to establish a furnace near Jamestown in 1622, but it failed on account of Indian troubles.

We are indebted to Mr. Woodbury for the photograph of the casting, and to his excellent address for the facts briefly noted above.

THE GARIBALDI BRIDGE AT ROME.

The accompanying illustrations show the Garibaldi Bridge at Rome, which crosses the Tiber near the historical island called Isola Tiberina, which is said to have been formed by the mass of grain plundered by the population in a revolt against the Tarquins. Tradition has it that the god Esculapius hid himself in this island in the disguise of a serpent, which the priests had captured in a Greek temple and brought to Rome in order to avoid a plague. This island was afterward cut to the shape of a vessel, and there was built the temple of Esculapius, of which are still to be seen the remains.

The bridge has a total length of 470 ft., and is formed with two large iron arches of 173 ft. 8 in. chord and 16 ft. 4 in. pitch. The distance between the parapets is 65 ft. 6 in. Each span is composed of 13 arched ribs, and the pavement is of stone. The central pier is 110 ft. 6 in. long, 39 ft. 3 in. wide at the top, and 46 ft. wide at the base. The abutments and the central pier were put in place upon foundations sunk by means of compressed air caissons to a depth of 50 ft. below low-water level of the river, and rest upon a layer of compact sand. The foundations of the abutments and central pier have required 29,925 cubic yards of masonry, while 2,930 cubic yards of *travertino* and 1,007 cubic yards of Baveno granite have been used for the ornamental portions.

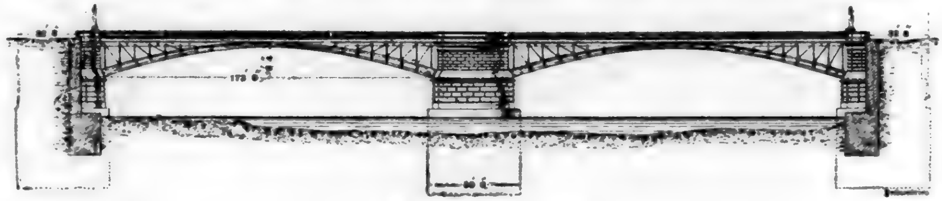
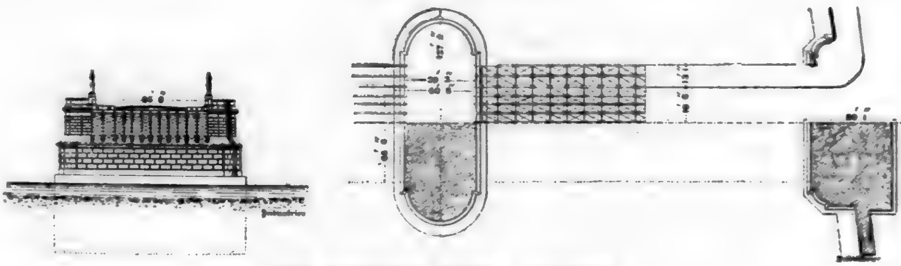


Fig. 1.—Side Elevation of Bridge



THE GARIBALDI BRIDGE AT ROME.

The weight of iron used in the construction of the two arches is 1,680 tons. A maximum load of 880 tons on the bridge gives a stress of 8,450 lbs. per square inch on the iron-work. This bridge cost about $720,000, of which $200,000 has been expended upon iron-work. At the two ends of the bridge there are four granite columns of the ancient *miliarie* form, bearing in bronze the dates of the principal campaigns of Garibaldi—Montevideo, 1847; Roma, 1848; Varese, 1859; Marsala, 1860; Volturno, 1860; Bezzecca, 1866; Mentana, 1867; Digione, 1871.

This bridge was designed by Signor Angelo Vescovali, who holds the position of Chief Engineer of the hydraulic service of the city of Rome—who designed the Margherita and Magliana bridges—and the works have been executed under his supervision by Messrs. Zschokke & Terrier. The iron-work was supplied by Messrs. Tardy & Benech, of Savona.

THE LIFE-SAVING SERVICE.

The General Superintendent of the United States Life-Saving Service, in his report for the year ending June 30 last, states that there were at the close of the fiscal year 242 stations, 181 being on the Atlantic, 48 on the Lakes, 12 on the Pacific and one at the Falls of the Ohio, Louisville, Ky.

The number of disasters to documented vessels within the field of the operations of the Service during the year was

337. There were on board these vessels 2,570 persons, of whom 2,550 were saved and 20 lost. The number of shipwrecked persons who received succor at the stations was 747, to whom 1,847 days' relief in the aggregate was afforded.

The estimated value of the vessels involved in the disasters was $5,584,160, and that of their cargoes $2,700,365, making a total value of property imperilled $8,284,525. Of this amount $7,111,005 was saved and $1,173,520 lost.

The number of vessels totally lost was 59.

In addition to the foregoing there were during the year 170 casualties to small craft such as sail-boats, row-boats, etc., on which there were 353 persons, 346 of whom were saved and 7 lost. The property involved in these instances is estimated at $67,810, of which $63,470 was saved and $4,340 lost.

In addition to the number of persons saved from vessels there were 36 others rescued who had fallen from wharves, piers, etc., and who would have perished without the aid of the life-saving crews. The crews saved without outside assistance 167 vessels, valued with their cargoes at $736,345 and assisted other efforts in saving 101 vessels, valued with their cargoes at $2,942,340, making the aggregate number of vessels saved during the year 268, involving $3,678,685.

Assistance of minor importance was rendered to 213 other vessels in distress, and 265 vessels were warned from danger by the signals of the patrolmen.

The cost of maintenance of the Service during the year was $1,009,234, a sum which has been well and judiciously expended. There are few departments of Government work which will be so generally approved as this, and certainly few in which good results have been secured at so moderate a cost.

Since the last report stations have been established and put in operation at Burnt Island, near the mouth of St. George's River, Maine; Quonocontaug, Rhode Island; Fenwick's Island, Delaware; and Ilwaco Beach, Washington; and a station is in process of construction at Brant Rock, Massachusetts. A station is also in course of construction on the grounds of the World's Columbian Exposition, to take the place of the old Chicago station. This station will also be utilized for exposition purposes during the World's Fair.

Repairs and improvements have been made at a number of stations, and a telephone line has been established between Cape Charles, Va., and Assateague Island.

The General Superintendent expresses his gratification upon the passage at the last session of Congress of the act increasing the compensation of the keepers and surfmen during employment at the stations. He states that its good effects are already apparent in the fact that in all instances men of the very best qualifications for the work of the Service are now obtainable, and the officers in charge find themselves able to dispense with some inferior men whom the rate of compensation formerly prevailing compelled them to take. Moreover, the men accept with greater cheerfulness the hardships and privations of their calling, and an improved *esprit de corps* throughout the Service is obvious.

THE NATIONAL LEAGUE FOR GOOD ROADS.

In reply to many inquiries, the National League for Good Roads makes the following statement of its plans for work:

1. To combine, as far as practicable, the efforts of all persons now engaged in the work for road reform.
2. To awaken interest in the subject among the people at large.
3. To receive, publish and discuss any well-considered plans for local, State or national action or legislation.
4. To urge the passage by the House of Representatives of the Senate's bill for a national highway.
5. To aid in providing for a proper road exhibit and for free instruction in road making at the World's Fair in Chicago.
6. To establish the league upon the broadest possible basis throughout the country, so that its influence may be of weight in any direction in which it may ultimately be thrown.

The temporary management does not feel authorized to adopt any line of policy nor commit the league to any special scheme which might antagonize the partisans of others, and thus defeat its immediate purpose to unite and solidify the movement.

The immediate formation of county leagues is recommended as a step toward the spread of the organization into township and school districts. County secretaries will be appointed by the State roads upon the recommendation of prominent citizens.

Until the State boards are fully organized all correspondence will be conducted through the General Headquarters, 45 Broadway, New York.

All State, county and local leagues are at liberty to act independently in local matters of road improvement, and will be supported by the national organization as far as is practicable and proper.

HOME NAVAL NOTES.

The new ordnance department of the William Cramp & Sons Ship & Engine Building Company is at work on a large contract for Driggs-Schroeder 6-pdr. rapid-fire guns for the Navy. The first lot of these, 12 in number, was recently completed and accepted, after undergoing the usual test. The 6-pdr. guns are 2.224 in. caliber.

The use of a new type of ram for coast defense is proposed by Commodore Folger, Chief of the Ordnance Bureau. The proposed ship differs from the Ammen ram somewhat in form, and also in carrying guns, with which the Ammen ship is not provided. The new type of ram is shown in the

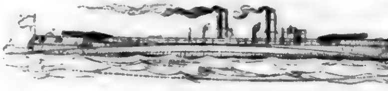


Fig. 1

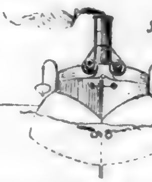


Fig. 2.

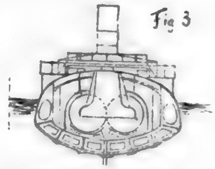


Fig 3

accompanying sketch, fig. 1 being a side view; fig. 2 a view of the bow, on a larger scale, and fig. 3 a cross-section amidships. It will be seen that the ship somewhat resembles the whaleback type in general form. She would be protected by water-line armor and a heavy curved deck. A ship of this type 275 ft. long and 45 ft. beam would have about 2,700 tons displacement. As a ram she would, of course, carry heavy engines, capable of giving her a speed of 18 or 19 knots. The armament proposed for such a vessel is four 9-in. or 10-in. rifled mortars, intended to carry shells loaded with high explosives; also two Ericsson submarine guns of 12-in. or 15-in. caliber. The vessel, in fact, seems to be intended to combine the qualities of a ram and a torpedo-boat.

The transfer boat *Ann Arbor*, No. 1, built to carry cars across Lake Michigan, has been inspected, and will probably be enrolled as one of the reserve vessels of the Navy. This boat, which was described in the Journal for November last, is especially suited for naval work. The heavy main deck, built to carry loaded freight cars, is well adapted for heavy guns, while the great strength of the hull and the wooden backing extending for 30 ft. from the bow, meant to enable her to break through the ice in winter, will, with her twin screws and powerful engines, make her a formidable ram, should her services ever be needed in a warlike way. She is also sheathed along the water-line with heavy boiler-plate, and has room for a large coal supply and a numerous crew.

The bids for the construction of the armored cruiser *Brooklyn* and the battle-ship *Iowa* were opened at the Navy Department, December 15. The *Brooklyn* is to be very similar to the *New York*, and the *Iowa* to the three battle-ships now under construction ; but some modifications were made in the designs from the earlier types, and the battle-ship is larger.

Four firms presented bids, all being made on the designs prepared by the Navy Department, except as noted. These bids were as follows :

	Brooklyn.	*Iowa.*
Bath Iron Works	$3,165,000	$3,185,000
Newport News Shipbuilding Co.	3,147,000	3,233,300
Union Iron Works, San Francisco	3,050,000	3,150,000
William Cramp & Sons Ship and Engine Co.:		
1. On Department designs	2,986,000	3,010,000
2. With quadruple-expansion instead of triple engines	3,086,000	3,110,000
3. On lines of *New York* and *Indiana* respectively	2,880,000	2,880,000

The Newport News Shipbuilding Company appears as a bidder for the first time. The other bidders all have naval work on hand.

It is understood that the Secretary of the Navy has at last decided that the *Vesuvius* should have a thorough trial with loaded shells. The previous partial trials for range and accuracy of the dynamite guns have been made with dummy or unloaded shells, but in the new trials a considerable number—75, it is said—of loaded shells will be used, and a full opportunity for testing their efficiency will be given.

The report of Commodore Farquhar, Chief of the Bureau of Yards and Docks, states that permanent improvements have been made at several of the navy yards, although the appropriations have not been large enough to do all that appears desirable.

The report says that there is a great necessity for a dry dock on the New England Coast capable of taking the largest battle ships, and he points to the possibly disastrous results of a naval combat off that coast without facilities for repairs. The same could be said of the necessity of a dry dock on the Gulf Coast.

In the report stress is laid upon the necessity for an increase in the number of civil engineers to meet the demands of the service, and legislation is suggested looking to the increase of the corps to twenty, twelve to be civil engineers and eight to be assistant civil engineers, the assistants to be selected from graduates of the Naval Academy showing an aptitude for civil engineering and given a course in some civil engineering school. Vacancies in the grade of civil engineers should be filled by promotion from the grade of assistants, after examination.

The annual report of Engineer-in-Chief George W. Melville shows the large amount of work done by the Bureau during the year in construction of new engines and in designing machinery for the new ships which have been authorized. The engines for the *Brooklyn* have already been described, and the other work has been referred to from time to time.

Mr. Melville recommends an appropriation of $25,000 for experiments with liquid fuel, in view of the many considerations in favor of the use of such fuel in ships. He also recommends that the present compound engines of the *Chicago* be replaced with new ones of a more modern type, which will add largely to the efficiency of the ship, and can be made to increase her speed, with considerably less weight and space than the present machinery.

The report renews the recommendations of last year for an increase in the number of engineer officers. Notwithstanding the greater variety of machinery on the new ships, the number of engineers has not been increased, and the amount of work and responsibility has become too great to permit a proper distribution. The need of more engineers is urgent for the ships already completed, to say nothing of those approaching completion ; and the present law does not take account of the fact that the modern naval vessel depends upon her engineers almost entirely for her efficiency. Mr. Melville speaks plainly in his report, and his argument is a strong one. An increase in the number of machinists and petty officers in the engine-room is also much needed.

The report of the Chief of the Bureau of Ordnance gives at length an account of the armor tests which have been from time to time described in our columns. In view of the results obtained in these tests it is believed that the tendency manifested abroad to decrease the caliber of the larger guns is to some extent unwise, and that great mass in the projectile will still be required to pierce the best qualities of armor as now made.

Of the 381 guns, of calibers from 4 to 13 in., required, 237 have been completed and 116 are already afloat.

The first 13-in. gun is approaching completion, and the forgings for a second one have been received.

Five 12-in. guns have been completed, of which two have been proved and are being installed on the *Monterey*. The test of this caliber upon the firing ground was entirely satisfactory.

All the 10-in. guns required have been completed and are ready for installation on the ships to which this caliber has been assigned.

A marked step in advance has been made in the application to the 10 in. and 12-in. guns of a device for operating their breech closure by hand. After considerable trial and experiment a simple and efficient mechanism has been developed, and thereby not only is the rapidity of fire of these heavy guns considerably increased, but the apparatus for working them is much simplified. The serious disadvantages attending the use of power, whether hydraulic, electric or other, in the working of naval ordnance are now generally recognized, and, as far as practicable, the Bureau proposes to use hand power for operating heavy guns.

All the 6-in. guns required to arm ships building or authorized have been completed, but the Bureau has contracted for forgings for six 6-in. guns of 40 calibers length o bore, which it proposes to make rapid-fire guns, using brass rtridge cases similar to those of the 4-in. and 5-in. rapid- e guns. These will be supplied to certain of the fast cruising vessels.

The metallic cartridge cases now adopted for the 4-in., 5-in., and 6-in. calibers will probably before long be applied to the larger calibers as well. The Bureau is convinced that it is merely a question of time before this innovation will be a definitely recognized necessity in the military services of all nations. The advantages of doing away with the obturator, of eliminating sponging, of replacing present powder tanks in the magazines by cartridge cases as fixed ammunition and the increase in rapidity of fire are too obvious to need discussion.

The manufacture of brown powder for the Navy has been continued. No changes in the requirements of the powder have been made, 2,000 feet-seconds, 2,100 feet-seconds, and 2,175 feet-seconds, respectively, being demanded in guns of 30, 35, and 40 calibers length of bore, the maximum pressure in no case to exceed 15 tons per square inch. With these requirements powder is supplied without difficulty for the guns of 8-in. caliber and less, and for 10-in. guns enough powder has been accepted to supply ships completed, but as yet no entirely satisfactory 12-in. powder has been tested. The difficulty would undoubtedly be removed by allowing an increase of pressure to 17 tons, and this is the usual limit abroad ; but the Bureau prefers not to do this on account of the considerable increase of the gun's life which will result in the use of only moderate pressures, and it is thought that finally powder up to the specifications will be supplied for the larger calibers with as uniform success as it already is for the smaller.

Since the last report marked progress has been made in the development of the Navy smokeless powder. At that date tests had been made only in small arms—3-pdrs. and 6-pdrs., and once in the 4-in. rapid-fire gun. During the past year 1,500 lbs. of smokeless powder, made at the torpedo station at Newport, have been tested in various ways with most gratifying results.

The square flat grains first used have been given up and the macaroni form adopted, the diameter of the sticks vary-

ing from $\frac{1}{32}$ in. for the small arms to about 0.2 in. for the 6-in. gun, and the larger of the sticks being perforated. Repeated experiments have further demonstrated the stability and safety of this powder. One portion placed in an iron vessel, wrapped in felting and exposed to a temperature of 208° Fahrenheit for six hours, was absolutely unaffected; another, similarly treated, stood a temperature of 212° Fahrenheit for 20 hours before showing signs of change; a third sample exposed to a temperature 5° below zero, Fahrenheit, was likewise unaffected. Attempts to detonate this powder by the service detonator, when closely confined in iron cylinders, have failed, though the cylinders themselves were ruptured and the powder scattered.

Other features treated by the report are the use of emmensite as a high explosive bursting charge for shells, the manufacture of armor-piercing projectiles, the fire of submarine guns, and the development of torpedoes.

THE gradual disappearance of the wooden vessels of the old Navy is forcibly shown in the annual report of Chief Constructor T. D. Wilson.

During the past year the *Pensacola* and *Iroquois* have been put out of commission, and the *Tallapoosa* condemned and sold. The *Kearsarge* and *Hartford* have been exempted from the operation of the 10 per cent. limit for repairs. There are only nine wooden steam vessels in active cruising service—viz., *Lancaster*, second rate; *Marion, Mohican, Kearsarge, Adams, Alliance, Essex*, and *Thetis*, third rate, and *Yantic*, fourth rate. The following vessels are in ordinary subject to the action of the Department: *Pensacola, Omaha, Swatara*, and *Iroquois*, all of which are at the Navy Yard, Mare Island. During the past year the *Nipsic* has been fitted out as quarters for officers on duty at the new naval station on Puget Sound. The *Enterprise* is to be turned over to Massachusetts as a nautical schoolship. The only wooden vessels remaining on active duty are the *Portsmouth* and *Monongahela*. The *Monongahela* has been completely overhauled during the past year, has had a spar deck added, and is now a most efficient and serviceable training vessel. The *Jamestown* has been found unfit for further active service, and is now being temporarily used as a hospital ship at Cape Charles, Va. The progress of work on vessels under contract and those building at Navy yards is on the whole satisfactory, but, in many instances, has been greatly impeded by the delay in supplying armor-plates. It is believed, however, that the contractors for armor are now in a position to fulfil their contracts with greater rapidity and that delay from this source will soon disappear. Fourteen new vessels, including three tugs, were launched during the year—the *Detroit, New York, Montgomery, Machias, Narkeeta, Wahneta, Iwana, Raleigh, Bancroft, Castine, Texas, Columbia*, and *Marblehead*. The tugs *Iwana, Wahneta*, and *Narkeeta* have had successful trial trips and have been accepted by the Navy Department. The others are in an advanced state of progress and, with the exception of the *Texas*, will probably have their trial trips within the next year. The following estimates for improvement of Navy-yard plants are submitted: $25,000, Portsmouth, N. H.; $30,000, Boston; $100,000, New York; $45,000, League Island; $120,000, Norfolk; $140,000, Mare Island. The Bureau renews its former recommendation that all new ships of the Navy should be subject to progressive speed trials, supplemented by turning trials whenever practicable, and again asks for an experimental tank.

The appointment of an Assistant Chief of Bureau, who shall have authority to act in the absence of the Chief, and an increase of pay to Chief Clerk and Chief Draftsman, are earnestly recommended. In view of the increasing demand for the services of carpenters as new ships are put in commission, it is urgently recommended that appointments be made to fill the vacancies now existing, and that the minimum number be re-established at 51, the number on the Navy Register in 1886. In conclusion the Bureau urges upon the Department the necessity of continuing the recent liberal policy of thoroughly equipping the various Navy-yards for all kinds of building and repair work, and training a force of skilful mechanics capable of doing the intricate and difficult work necessary in the construction and repair of modern ships of war.

THE report of the Secretary of the Navy includes a review of the work of the Department under his administration, necessarily repeating much that has been published before. Although this part of the report is interesting, its repetition here is hardly necessary. The Secretary's recommendations for the future we give, as follows:

"Another year of experience, of discussion and of criticism, both at home and abroad, confirms the Department in the views which it adopted in the annual report of 1889 as to the policy of construction which the Navy should pursue. The policy then advocated, which was a radical departure from any view previously presented in this country, consisted in the production of three principal types: First, the armored battle-ship of 10,000 or more tons; second, the armored cruiser of from 8,000 to 9,000 tons, and, third, the commerce protecting and destroying cruiser, of extreme speed, of 7,500 tons.

"Before the first battle-ships were undertaken the number required was fixed at 20. In the report of 1890 it was stated that such was the great power, both offensive and defensive, of the design evolved that the Department could safely modify its previous figure, and that 12 such battle-ships as were then in course of construction would equal in efficiency for our purpose the 20 that were previously contemplated. Four have now been authorized, and it remains to provide eight more, or 12 in all, of which eight should be stationed on the Atlantic Coast and four on the Pacific."

[Secretary Tracy deprecates the building of unarmored cruisers between 4,000 and 5,000 tons, and recommends the construction of several torpedo cruisers of 22-knot speed and 800 to 1,000 tons displacement; also of four 1,200-ton vessels for river services.]

"I would also renew the recommendation previously made for the building of torpedo boats. A supply of American torpedoes is now at hand, and the United States cannot afford to be any longer destitute of the boats specially adapted for their use. At least 30 such boats should be constructed in the immediate future.

"The problem of reorganization of the Navy is yearly becoming more pressing, and delay in action renders it more difficult of solution. It is clearly impossible to deal adequately with the subject in its reference to only one branch of the service, and I therefore recommend that it be referred to a Congressional commission, empowered to deal with the question as a whole, and that the various measures proposed for reorganization of the service or any part of it be considered by this commission. In addition I would urge the passage of legislation at this session which shall give to the Navy the benefit of the laws long applied to the Army, by which an officer may retire after 30 years' service on his own application in the discretion of the President, and shall be allowed commutation for quarters where no quarters are provided.

"Of all the changes in organization made by this administration the most important is that which relates to the employment of labor at the Navy yards.

"For the selection of workmen a board is established at each yard composed of the captain of the yard and two of the officers of technical departments, who act as a board of registration to classify all workmen who apply in their several trades and register them for certification to departments requiring workmen. Upon the receipt of requisitions from a department requiring men the Board is required to furnish them in the order in which they stand on the register—that is to say, in the order of their application.

"Under these rules the Navy yards have now been conducted for 15 months. During these 15 months occurred a Presidential campaign, the first within the memory of the present generation in which the yards have not been used as a political machine. In all departments of labor and at all the yards the question whether a man was a Republican or a Democrat has been absolutely and totally ignored. The foremen, whether new or old, are to-day in every case the foremen recommended by the Board; and the old had no advantage in the selection, for every foremanship was vacated before the selection was made. Not a workman has been taken on except in accordance with the rules; and while in former Presidential campaigns the yards have been packed with voters, in the last no increase whatever took place during the 60 days before the election, nor was a

workman employed beyond the normal number. The evidence of increased efficiency under this system is clear and unequivocal.

"The estimates for the fiscal year ending June 30. 1894, for the Navy and the Marine Corps, including those for public works and for increase of the Navy, amount to $24,471,498, being $2,713,141 less than those for the fiscal year ending June 30, 1893.

"The estimates for the running expenses of the Navy and Marine Corps for the fiscal year ending June 30, 1894, amount to $14,767,841, being $135,943 less than the estimates for the fiscal year ending June 30, 1893.

"The estimates for the increase of the Navy amount to $9,703,657 for the fiscal year ending June 30, 1894, and are $2,577,198 less than those for the fiscal year ending June 30, 1893."

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 565, Volume LXVI.*)

Ocular demonstration being always more satisfactory than description, those readers who have been sufficiently interested in the subject to try the experiments which have been described with paper planes (falling by gravity) may also like to see for themselves how an aeroplane behaves when motive power is applied. They can probably obtain in a shop one of the toys which have already been alluded to, under the head of "Screws to Lift and Propel," as one of the series produced in 1879 by M. *Dandrieux*, and which is shown in fig. 59.

This is a true aeroplane, the wings being fixed, and the propulsion being produced by the screw at the front, which

Fig. 59.—DANDRIEUX—1879.

represents the antennæ of the butterfly. This screw is driven by the unwinding of the rubber threads, and has practically no pitch except that produced by the yielding of the posterior edge of the gold-beater's skin, of which the vanes are composed. Its peculiar shape, giving a maximum of surface near the outer end, with a rigid anterior edge and an elastic posterior edge, is the result of a good deal of experiment, and may furnish a useful hint for those desiring to experiment upon a larger scale. The wings are also of gold-beater's skin, and instead of being stretched tightly upon the frame, the anterior margin only is made rigid, the rest of the surface being left quite loose, so that it may undulate when under forward motion, as in the case of M. *Brearey's* device, which will presently be described. This feature in construction, which differs greatly from that which obtains in the case of birds and insects, whose wings are elastic, but do not undulate, is said to be intended to compensate for defects in workmanship and equilibrium. Upon being tested in still air within doors, the toy will be found quite erratic in flight. It will generally go up to the ceiling, and then flutter in various directions until the power is exhausted, and seldom twice pursue the same course. Out-of-doors it will rise some 20 or 30 ft., dart about, or drift with the wind, until the rubber threads are unwound, and then glide down to the ground sustained by its aeroplane alone.

As a matter of course the sustaining surfaces have to be made very large in proportion to the weight, in order to prevent injury in alighting. One of these little toys, computed by the writer, weighs 86 grains or 0.0123 lbs., and measures 50 sq. in. in aeroplane surface, or 0.3472 sq. ft.; this being in the proportion of 28 sq. ft. to the pound, or about 0.7 of that of the real butterfly, which, being much smaller, measures some 40 sq. ft. to the pound, and which in consequence is capable of but slow flight, although it is not infrequently found by aeronauts floating about in the upper air a mile or so above the earth, a fact to which further reference will be made when we come to consider the prevalence of upward trends in aerial currents.

The propulsion of a loose undulating surface was at about the same time, somewhat differently and quite inde-

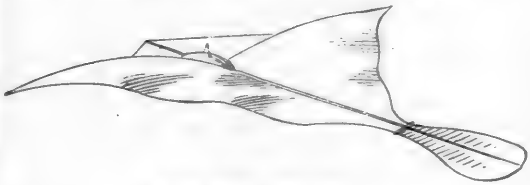


Fig. 60.—BREAREY—1879.

pendently, proposed by M. *F. W. Brearey*, the Honorary Secretary of the Aeronautical Society of Great Britain. He patented, in 1879, the apparatus shown in fig. 60, in which a flexible fabric is attached to a central spine and to vibrating wing arms at the front, which latter beat up and down like the wings of a bird. The effect of this action is to throw the fabric into a state of wavelike motions, both lengthwise and in a smaller degree also laterally, which are said to cause the apparatus to be both supported and propelled in the air, while an adjustable tail regulates the angle of incidence. The wing arms are flexible and stayed to a bowsprit by cords, and the power for an actual machine is to be placed in a car or body affixed along the central spine.

M. *Brearey* records that he took the idea from watching the movements of a "skate" fish in an aquarium, which in swimming undulated its whole body, and that he found that when applied to propulsion in air the loose fabric greatly added to the stability, so that the device might be considered as a sort of dirigible parachute, which would come down safely if the motive power became exhausted from any cause. In the various models which he made to illustrate the experimental lectures, with which he was accustomed to popularize "the problem of flight" in Great Britain, he used the torsion of india-rubber to produce the revolution of the crank which vibrated the arms, thus getting a dozen strokes or so, and he claimed that the smaller model (5 ft. × 8 ft.) flew from his hand, on one occasion at least, perfectly horizontally to the extent of 60 ft., no angle of incidence of the apparatus being perceptible. The larger model was 6 ft. wide by 10 ft. long, with about 16 sq. ft. of surface, and a weight of 3.1 lbs. (of which 0.44 lbs. was added ballast, which it easily carried), being thus in the proportion of some 5.15 sq. ft. per pound of weight, with which the falling velocity would be about 9 ft. per second, or equal to a descent from a height of 1.27 ft., but which was nevertheless found to be too heavy to be safely used in public experiments over the heads of an audience. From his experiments M. *Brearey* drew the following conclusions as to the possibilities of his apparatus:

We are thus at liberty to contemplate the construction of an aerial vehicle whose dimensions would suffice to maintain, in wave-action, 600 or 700 square feet of canvas, actuated by

steam-power, and capable of supporting the additional weight of a man, whose weight, together with the machine, would certainly not exceed 500 lbs.; and we can contemplate the man as being able to move a few feet backward or forward without much affecting the stability of the machine. His descent under the parachute action can thus be graduated at will. This can also be effected by a cord attached to the tail, which by that means can be elevated or depressed at pleasure. Placed upon wheels it has, of course, yet to be ascertained what distance of preliminary run would be required, assisted by the action of the fabric, before it would rise from the ground.

Subsequently (his second American patent is dated in 1885) M. *Brearey* further proposed the superposition of two or more sets of such "wave-action" aeroplanes, and the important addition of what he calls the "pectoral cord," which consists in an elastic cord (or suitable spring) attached to some point underneath each of the lower set of wing-arms and passing underneath the carriage, car or central spine, so that it may be thrown into tension on the up stroke, and restore the power thus stored upon the down stroke of the wing-arms. This device is designed to imitate in its action the functions of the pectoral muscle of a bird. The tension of this cord or spring is regulated in accordance with the weight to be sustained, and is said to be perfect when, upon the whole apparatus being committed free to the air, the wing-arms are retained at a suitable diedral angle against the upward pressure. It follows from this action that the up stroke, being assisted by the air pressure which sustains the weight of the apparatus, expends less power than the down stroke, and that nearly all the power can be used in depressing the wing-arms to compress a wave of air, which undulating backward and outward along the loose fabric may assist the air pressure already due to the forward speed, in sustaining the aeroplane, and serve at the same time to propel it.

M. *Brearey*, however, seems to have applied this "pectoral cord" chiefly to those of his models which showed the wing-action proper, and in the practical demonstration which he gave to the Aeronautical Society of Great Britain, at its meeting in 1882, he said:

Working in the field of experiment, I am enabled to state that the power requisite to propel and sustain a body in the air has been greatly overestimated, even by those who took the more favorable estimate in view of the ultimate attainment of flight. I am not aware, however, that the true reason for the minimum display of actual power exerted in the flight of birds has ever been propounded. Certainly it has never before been demonstrated by actual experiment.

The action of the pectoral muscles of the bird alone accounts for this. Consequently the advantage would be altogether lost in anything but a reciprocal action. The bird commits himself to the air, and the pressure of the air underneath the wings forces them upward. The weight of the bird is indicative of the pressure; and as a consequence of this automatic raising of the wing by the pressure of the air underneath, we should imagine that the elevator muscle need not be strong. As a matter-of-fact, we find it is weak. I doubt whether any muscular effort is made to elevate the wing at all in flight; but when not in flight, the bird of course requires the power to elevate its wing in preparation for it.

Committed, then, to the air, the elastic ligaments connected with the wings are stretched to that degree which allows of the wings being sufficiently raised for effective support without flapping, and without, as I conceive, any muscular exertion upon the part of the bird. The limited power of the elevator muscle may here come into use occasionally in aid of the under air-pressure, and with the further effect of stretching the ligaments. Now it will be argued that in the downward stroke there must be as much muscular force employed as will raise or, at least, prevent from falling, the weight of the bird; but this is not so, because the reaction of these ligaments, which have been stretched entirely by the weight of the bird, assists materially the action of the depressor muscle. . . . . .

M. *Brearey* here produced a model having wings measuring 4 ft. from tip to tip. He showed the elastic cord underneath the wings, but for the purpose of the first experiment he detached it. He then wound up the india rubber strands 32 times, and showed that this, although sufficient to flap the wings with energy while held in the hand, was insufficient to cause the model to fly. This was demonstrated by letting the model free. He explained its inability to fly from its want of power to bring the wings down with sufficient force.

He now unwound the action and proceeded to wind it up again 32 times, and attached the pectoral cord. Holding the model in his hand, he called attention to the fact that it was powerless to flap the wings because the two forces were in equilibrium. It required the addition of another force to effect flight, and he asked what that other force could be except weight? If now it flew, he proved beyond the possibility of doubt that weight was a necessity for flight. The model was then set free, and flight was accomplished.

He also showed that the model would only fly without the attached pectoral cord when wound up 40 times. With the cord it would fly when wound up only 13 times, thus showing the great saving in power which accrued through the action of the pectoral cord.

M. *Brearey* then produced a model of his "wave aerial machine," having 4 sq. ft. of loose surface weighted to ¼ lb., and he demonstrated by its flight that the principle was equally applicable to that.

It may be questioned whether this "wave action" is likely to prove economical of power in either sustaining or propelling an aeroplane, for it seems difficult to conceive that a wave of air compressed at the front by the wing-arms should travel back to the rear, unconfined as it is either at the bottom or sides. Still, the loose surface may add to the stability, as claimed for the *Dandrieux* toy, and it would certainly diminish by its yielding the strains that would otherwise occur at the points of attachment of a rigid surface in an aeroplane; but M. *Brearey's* wave-action seems to be chiefly applicable as a dirigible parachute, and a small model upon this principle, but without motive power, was once liberated as an experiment by Captain *Templer*, from a balloon which had risen 200 ft. or 300 ft. from Woolwich Arsenal, and it traveled back again to the arsenal, half a mile, against the wind.

It seems somewhat singular that so few efforts have been made to devise dirigible parachutes, a system which M. *de la Landelle* constantly extolled, as constituting the first requisite step toward eventual flight by working out the problem of absolute stability and safety. The only one of these devices which the writer has been able to find recorded is that of M. *Couturier*, patented in France in 1875, and this is so briefly described in the *Aéronaute* for November, 1878, that its mode of operation cannot be made out.

The "pectoral cord" attachment is probably a valuable device for flapping wings, as furnishing that inequality of effort between the up and the down stroke which undoubtedly obtains in bird flight. This effect was produced in a "wave-action" model exhibited by M. *Brearey* at the aeronautical exhibition of the Aeronautical Society of Great Britain of 1885, by a "trunk engine" designed and built by M. *Hollands*, which, however, was not shown under steam, as the boiler was only just completed in time for the exhibition; but M. *Hollands* said that the model flew well, and supported weights, when the engine was supplied with compressed air through an india-rubber tube. He does not seem to have stated what power was exerted.

While almost all inventors and experimenters of aeroplanes have proposed some sort of motive power, and have found their designs paralyzed very soon by the want of a sufficiently light motor, there have been at various times, as already intimated, keen observers of the flight of soaring birds, who have held that once under way in a sufficient breeze, the performance involves no muscular movement whatever, save in balancing, and that the wind alone furnishes sufficient motive power (if blowing from 10 to 30 miles per hour) to enable man to soar and to translate himself at will in any direction, even (paradoxical as it may seem) against the wind itself.

Chief among these observers in recent days stands M. *Mouillard*, of Cairo, Egypt, who has spent over 30 years in watching birds soar in tropical latitudes, and who published, in 1881, a very remarkable book (in French), "L'Empire de l'air," which should be read by all those seriously interested in the solution of the problem of flight. This book, the result, as the author explains, of a passionate vocation which began at the age of 15, is almost wholly a record of personal observations and deductions. Its subtitle designates it as an "essay upon ornithology as relating to flight," but it is far more than that, for it not only de-

scribes the flight and manœuvres of birds, and gives good reasons for the author's belief that they can be imitated by man, but it describes four attempts which he has made to do so with various forms of apparatus.

M. *Mouillard* underrates, perhaps, the value of mathematical investigation, and he sometimes errs in his explanation of physical phenomena; but his observations are unrivaled, and they are presented with a particularity of circumstance, a vivacity and a charm which photograph them at once on the mind of the reader. He begins by explaining the difference between useful and unfruitful observations of creatures so willful, so swift, and so shy as the birds; then he describes the various modes of flight (both rowing and sailing), and the movements of the various organs, such as the wings and the tail; the influence of their shape in determining the mode of progression and the speed of the various species, and he shows conclusively that if these organs are properly shaped therefor, the heavier the bird the more perfectly he soars, and can, once initial speed is gained, *sail indefinitely upon the wind without further flapping his wings*. This is the keynote of the book; observation after observation is described, anecdote after anecdote is related, to impress upon the reader that there need be no flapping whatever, if only the wind be strong enough; and that when there is no wind, the soaring bird must come down to the ground or resort to flapping, like the rowing birds.

Then the effect of the speed of the wind is discussed. It is shown that certain species of soaring birds with broad wings, such as the kites, the eagles, and the vultures can sail upon a wind blowing at 10 to 25 miles per hour, but must seek shelter when it increases to a gale, while the seabirds, with long and narrow wings, such as the gulls, the frigate bird, the albatross, sport indefinitely in the tempest blowing at 50 or more miles per hour. He arrives at the conclusion that when man succeeds in imitating the manœuvres of the soaring birds, he will utilize the moderate winds, and attain to speeds of about 25 to 37 miles per hour.

M. *Mouillard* also passes in review the individual mode of flight and characteristics of the various species of birds, both the rowers and the sailers; comprising some 13 different types, and giving tables from his own measurements of weights, surfaces, dimensions, etc., which have been compiled by M. *Drzewiecki*, and have already been quoted by the writer under the head of "Wings and Parachutes:" while he finally expresses a strong opinion that the easiest type for man to imitate is the great tawny vulture of Africa (*Gyps fulvus*), which weighs some 16.50 lbs., and spreads some 11 sq. ft. of surface to the breeze.

M. *Mouillard* explains how, in his opinion, the manœuvres of this bird can be imitated, so as to obtain both a sustaining and a propelling effect from the wind, and he describes (much too briefly) the four several attempts which he had then made to demonstrate the correctness of his theory of the possible soaring flight of an aeroplane for man.

The third of these aeroplanes, as described in 1881, is shown in fig. 61. It consisted of two thin boards, properly stiffened, to which were attached ribs of "agave" wood

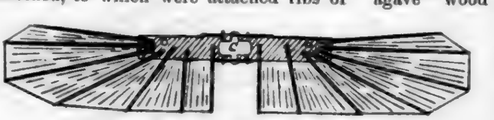


FIG. 61.—MOUILLARD—1865.

(an African aloe, exceedingly light and strong), which ribs carried the fabric constituting the two wings. The two boards were hinged vertically together (somewhat imperfectly) at the center, and the operator stood upright in the central space at *c*, suspended by four straps attached to the boards near the hinge; two of these straps passing over the shoulders and two between the legs. Moreover, light wooden rods extended from the feet to the outer ends of the boards, so that the angle of the wings with each other could be varied at pleasure.

Standing upright, with this apparatus strapped on, the hinge was about at the height of the pit of the stomach, the arms being extended out flat upon the boards, and slipping under straps; M. *Mouillard* trusting to such shifting of his body within the space *c* as he could effect by resting his weight on his arms, to produce the necessary changes in the center of gravity of the apparatus, which were required by the changes in the angles of incidence.

The whole apparatus weighed 33 lbs., but was found unduly light, as the parts yielded and the wood cracked when tested with vigorous thrusts of the legs. It had been hastily constructed, with such materials as the country afforded, and the builder was not satisfied with it.

M. *Mouillard* gives but a scanty description of his experiments with this aeroplane in "L'Empire de l'air," so little, indeed, as to suggest further inquiry; but he has since written another book, which he entitles "Le vol sans battements" (flight without flapping), which is now nearly ready for the press, and wherein he records further observations, explains more fully his ideas and the results of his meditations, giving freely, as he expresses it, "all that he knows," and in which there is a fuller account of the experiment in question.

From this forthcoming book M. *Mouillard* has kindly furnished the following extract concerning the experiment with the apparatus shown in fig. 61.

It was in my callow days, and on my farm in the plain of Mitidja, in Algeria, that I experimented with my apparatus, No. 3, the light, imperfect one, the one which I carried about like a feather.

I did not want to expose myself to possible ridicule, and I had succeeded by a series of profound combinations and pretexts in sending everybody away, so that I was left all alone on the farm. I had already tested approximately the working of my aeroplane by jumping down from the height of a few feet. I knew that it would carry my weight, but I was afraid to experiment in the wind before the home folks, and time dragged wearily with me until I knew just what the machine would do; so I finally sent everybody away—to promenade themselves in various directions—and as soon as their backs were turned, I strolled into the prairie with my apparatus upon my shoulders. I ran against the air and studied its sustaining power, for it was almost a dead calm; the wind had not yet risen, and I was waiting for it.

Near by there was a wagon road, raised some 5 ft. above the plain. It had thus been raised with the soil from ditches about 10 ft. wide, dug on either side.

Then came a little puff of wind, and it also came into my head to jump over that ditch.

I used to leap across easily without my apparatus, but I thought that I might try it armed with my aeroplane; so I took a good run across the road, and jumped at the ditch as usual.

But, oh horrors! once across the ditch my feet did not come down to earth; I was gliding on the air and making vain efforts to land, for my aeroplane had set out on a cruise. I dangled only one foot from the soil, but, do what I would, I could not reach it, and I was skimming along without the power to stop.

At last my feet touched the earth, I fell forward on my hands, broke one of the wings, and all was over; but goodness! how frightened I had been! I was saying to myself that if even a light wind gust occurred, it would toss me up 30 to 40 ft. into the air, and then surely upset me backward, so that I would fall on my back. This I knew perfectly, for I understood the defects of my machine. I was poor, and I had not been able to treat myself to a more complete aeroplane. All's well that ends well. I then measured the distance between my toe marks, and found it to be 138 ft.

Here is the *rationale* of the thing. In making my jump I acquired a speed of 11 to 14 miles per hour, and just as I crossed the ditch I must have met a puff of the rising wind. It probably was traveling some 8 to 11 miles per hour, and the two speeds added together produced enough pressure to carry my weight.

I cannot say that on this occasion I appreciated the delights of traveling in the air. I was too much alarmed, and yet never will I forget the strange sensations produced by this gliding.

Then M. *Mouillard* repaired the injured aeroplane, and he tried it again a few days later. Of this later experiment he says in "L'Empire de l'air":

I had no confidence, as I have already stated, in the strength of my aeroplane. A violent wind gust came; it picked me up; I became alarmed, did not resist and allowed myself to be upset. I had one shoulder sprained by the pressure of the

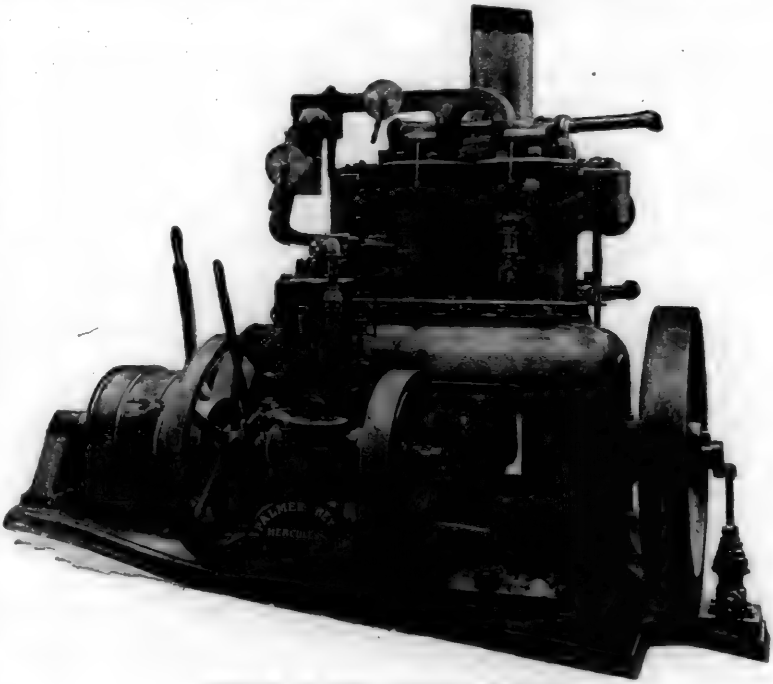
two wings, which folded up against each other like those of a butterfly when at rest.

M. *Mouillard* then determined to make no more experiments with this incomplete machine, but to build a better one, with which he could control all the manœuvres necessary for soaring, but shortly afterward his circumstances led him to leave the farm and to remove from Algeria to Cairo, Egypt. Here, in a great city, he no longer had the facilities for experimenting that he possessed on the farm, for he had to go out some distance to secure space and privacy for each experiment. Then came illness; the former gymnast became a cripple, so that he could no longer perform for himself the aerobatic manœuvres necessary to experiment with a soaring apparatus, but still he persevered, and he describes in "L'Empire de l'air" the design for the fourth apparatus, of which he began the construction in 1878, but which was interrupted by ill-health.

Since the publication of his book in 1881, M. *Mouillard* is understood to have been continuously engaged in perfecting and simplifying his proposed soaring apparatus, and in trying experiments (by proxy) with models on a small scale. He says that he will soon be prepared to have the matter tested on a large scale, and that he has never wavered from absolute conviction in the truth of the principles which he laid down in "L'Empire de l'air," in which he expresses himself as follows:

I hold that in the flight of the soaring birds (the vultures, the eagles, and other birds which fly without flapping) *ascension is produced by the skillful use of the force of the wind, and the steering, in any direction, is the result of skillful manœuvres; so that by a moderate wind a man can, with an aeroplane, unprovided with any motor whatever, rise up into the air and direct himself at will, even against the wind itself.*

*Man therefore can, with a rigid surface and a properly designed apparatus, repeat the exercises performed by the soaring birds in ascension and steering, and will need to expend no force whatever, save to perform the manœuvres required for steering.**



ENGINES OF THE "HIRAM BINGHAM."

The exact shape of these aeroplanes need not be discussed in this chapter, for it will be seen further on that there are scores of shapes and devices which can be employed, but all forms of apparatus, however dissimilar, must be based upon this idea, which I repeat:

Ascension is the result of the skillful use of the power of the wind, and no other force is required.

M. *Mouillard* then continues:

It will doubtless be very difficult for many persons to admit that a bird can, with a moderate wind, remain a whole day in the air with no expenditure of power. They will endeavor to suppose some undetermined pressures or some unseen flappings. In point of fact, the human understanding does not readily admit the above truth; it is astonished, and seeks for all the evasions it can find. All those who have not *seen* say, when ascension without expenditure of force is mentioned to them, "Oh, well, there were some motions which escaped your observation."

It even occurs sometimes that a chance or superficial observer, who has had the luck to see this manœuvre well performed by a bird, when he turns it over in his mind afterward feels a doubt invading his understanding; the performance seems so astonishing, so much against ordinary experience, that the man asks himself *whether his eyes did not deceive him.* For this observation, in order to carry absolute conviction, must bear upon the performance of the largest vultures, and they alone; and this is the reason: it is because all the other birds which ascend into the air by this process do not perform the necessary decomposition of forces required in all its naked simplicity.*

To be convinced, a man must *see;* for to see the performance even once is better than a whole volume of explanations. Therefore, O reader, if you are interested in this subject, go and see for yourself, and be edified. Go to the regions where dwell the birds which perform these demonstrations; and when you have beheld them for a few instants, being already initiated as to what to observe, comprehension will at once come into your understanding.

Whoever has seen a boy's kite ascend into the air, and considered that the string may be replaced by a weight, *if only the equilibrium be secured and maintained,* will have no difficulty in granting the correctness of M. *Mouillard's* assertion that the power of the wind is quite sufficient to secure ascension, but it will not so readily be understood how it is also sufficient to secure progression even against the wind. It will, indeed, be conceived that an aeroplane possessed of initial velocity can soar in a circle in the wind like a bird, and by changing its angle of incidence, descend somewhat when going with the wind, and rise again in consequence of the greater "lift" when facing the wind, thus gaining in height at every lap, and eventually utilizing the elevation thus gained in gliding in any desired direction, *always provided that the equilibrium be maintained;* but this involves very delicate manœuvres, which will be further considered when we come to sum up the results of all the experiments with soaring devices, and indeed the subject warrants a paper by itself, which may be placed in an appendix.

It may, however, be said here that the French aviators, after having long doubted the reality of the performance of sailing flight by the birds, whose evolutions they were unable to watch in their climate, have had so many corroborations furnished to them by trustworthy witnesses, that they

* The italics are M. *Mouillard's* own.

* The present writer has seen the feat performed by gulls many times.

now generally admit that a soaring bird can sustain himself indefinitely on a wind, without flapping, and that man may learn to imitate him if only a proper apparatus be designed, and the operator possesses the necessary knowledge and skill to work it, so as to perform the right manœuvres and at the right time.

(TO BE CONTINUED.)

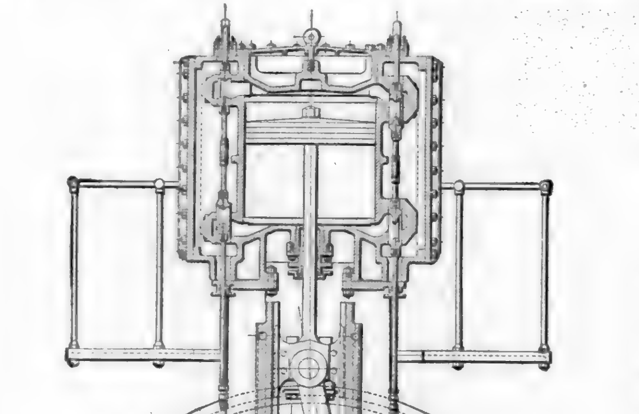
A SHIP WITH GASOLINE ENGINES.

(From *Industry*, San Francisco.)

THE *Hiram Bingham*, a vessel 50 ft. long, 14 ft. beam, fitted with full schooner rig, and also with gasoline engines of 25 H.P., by Messrs. Palmer & Rey, of San Francisco, sailed October 31 for the Gilbert Islands, *via* Honolulu. We were out on one of the trial trips of this strange vessel, and must confess to a modification of some previous views respecting propulsion by engines of the kind for boats of this size. Their performance was admirable, driving the schooner at 10 miles an hour without the least hitch of any kind, and running with a steadiness that could not be exceeded by a steam-engine. As may be seen from the plate above, made from a photograph of the *Bingham's* engines, the proportions, and all their connected gearing, is much heavier and stronger than is employed for stationary work, and so made in view of use in a distant land where there are no facilities for repairing, and not much for maintenance and care.

The engines were tested by Chief Engineer Kontz, U. S. N., at the works of Messrs. Palmer & Rey, and gave out over 31 H.P., or 24 per cent. more than the power contracted for. They were managed on the trial trips by Rev. Mr. Walkup, who is to take the vessel out to the Gilbert Islands, where he will employ her for missionary purposes.

It is a most remarkable adventure in several ways. Rev. Mr. Walkup has a scientific turn, and holds his certificate as a navigator, but to start across thousands of miles of wide ocean in a craft of this size with a crew of three persons—a Swedish mate and two natives of the Gilbert Islands—seems a remarkable venture, which we hope will turn out successful. At sea the sails alone will be used, unless in the case of a calm, the screw being disengaged so it will revolve free. There is fuel enough provided for emergencies, and a fresh supply will be taken in at Honolulu, if the vessel gets there.



VERTICAL COMPOUND ENGINE, BY THE LAKE ERIE ENGINEERING WORKS.

A NEW VERTICAL COMPOUND ENGINE.

ON account of the extremely severe service of engines for driving generators supplying current for electric railroads, lighting and power plants, the ordinary commercial engine heretofore used has been found inadequate to meet the demands of this service as regards regulation and sudden changes of load. Builders furnishing engines for this service have found it necessary to change their old designs in such a way as to make practically new designs, in order to meet these requirements.

A new type of engine, designed especially for this class of work, has been recently brought out by the Lake Erie Engineering Works of Buffalo, of which company the Field Engineering Company are the Eastern representatives. Illustrations of their standard design will be found herewith, the engravings showing a 500-H.P. vertical compound engine, having two cranks at 90° and with belted wheels. The design, however, is extremely flexible as regards the arrangement of wheels and cylinders for compound or triple expansion, either for belted work or direct connection to multipolar generators. The smaller cut is a general view of the engine, and the larger one is a section through the center.

The cast-iron columns are of the double-box girder type of A frame, securely bolted to the lower part of the cylinder and to the main pedestals, carrying brackets for valve rockers, and having the guides bolted to their inner faces. These guides are easily removed and renewed in case of accident. Each cylinder frame consists of two double columns secured to a main pedestal at the lower extremities and supporting the cylinder bolted to their upper ends. This main pedestal carries at each side a main bearing which is removable, and between these bearings the cranks are situated. A cylinder, its columns and main pedestal compose a unit. These units do not differ materially in the three cylinders of a triple or the four cylinders of a quadruple, except in the diameter of cylinders for their respective positions in the sequence of expansion. These units are placed on a common bedplate, extending to a sufficient distance below the shaft to allow the wheels or generators to be placed in any desired locality along the crank shaft. This bedplate is practically a sub-

LOCOMOTIVE RETURNS FOR THE MONTH OF SEPTEMBER, 1892.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage.					Av. Train.		Coal Burned per Mile.						Cost per Locomotive Mile.							Cost per Car Mile.		Cost of Coal per Ton.
			Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Passenger Cars.	Freight Cars.	Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Passenger.	Freight.	
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Alabama Great Southern	...	55	38,949	77,748	37,708	154,405	2,807	...	...	62.30	84.39	51.54	69.44	...	...	4.30	4.30	0.31	0.50	6.20	2.00	17.61	...	...	...
Alabama & Vicksburg	...	17	18,370	14,041	11,252	43,663	2,569	...	...	45.87	83.33	41.07	58.31	...	...	3.20	4.90	0.27	0.70	6.20	1.80	19.07	...	...	...
Atchison, Topeka & Santa Fé	834	738	...	...	434,719	2,309,909	3,130	...	...	...	...	...	81.20	...	...	4.73	6.50	0.28	0.12	6.59	1.40	19.64	...	...	1.54
Canadian Pacific	599	...	490,678	751,220	466,933	1,708,831	2,853	...	...	...	...	...	62.44	...	...	10.50	3.48	0.41	...	5.24	1.31	20.91	...	1.81	3.32
Chic., Burlington & Kansas City	12	11	13,510	27,771	...	41,281	3,753	3.03	12.80	...	...	...	81.53	21.21	10.08	6.34	5.48	0.21	0.26	6.05	...	18.34	...	...	1.36
Chic., Burlington & Quincy	525	...	...	...	...	1,919,799	3,657	5.21	19.63	...	...	...	82.71	...	...	4.18	5.38	0.24	0.17	6.66	...	16.63	...	...	1.31
Chic., Milwaukee & St. Paul	808	...	...	...	...	2,872,720	3,555	...	...	...	...	...	67.77	...	...	3.45	6.94	0.27	...	6.78	...	17.44	...	...	2.00
Chic., Rock Island & Pacific	553	...	612,516	1,050,465	420,262	2,083,243	3,767	...	...	54.45	76.04	39.72	62.00	...	...	2.73	3.75	0.28	...	5.98	0.39	15.08	...	...	1.60
Chicago & Northwestern	871	...	687,472	1,469,725	815,118	2,972,315	3,413	...	...	...	...	...	80.47	...	...	3.22	7.30	0.35	...	6.32	0.78	17.97	...	...	1.80
Cincinnati Southern	...	97	84,826	164,027	82,353	331,206	3,415	...	...	60.81	112.36	36.90	81.63	...	...	4.40	4.70	0.28	1.30	6.50	1.80	18.98	...	...	...
Cumberland & Penn.*	23	21	5,372	34,001	...	39,873	1,875	...	...	...	...	...	84.38	...	...	9.00	4.60	0.50	...	...	1.80	15.90	...	...	...
Delaware, Lackawanna & W. Main L.	208	197	...	...	...	683,449	3,709	...	...	...	...	...	79.36	...	...	3.31	6.19	0.38	...	5.86	...	15.74	...	...	...
Morris & Essex Division	159	...	166,519	224,590	13,182	404,691	2,543	...	...	...	...	...	60.88	...	...	4.22	9.50	0.42	...	6.42	...	20.56	...	...	3.11
Hannibal & St. Joseph	...	66	75,176	172,531	37,490	285,197	4,321	5.46	17.89	...	...	...	83.65	13.00	6.04	6.08	5.52	0.19	0.12	6.45	...	18.94	...	...	1.34
Kansas City, F. S. & Memphis	144	...	97,860	237,474	125,180	460,514	3,198	...	...	...	...	...	57.72	...	...	3.82	4.77	0.32	0.35	7.36	...	16.62	...	...	1.61
Kan. City, Mem. & Birm.	41	38	35,447	56,914	15,868	108,229	2,848	...	...	...	...	...	62.12	...	...	3.29	3.43	0.24	0.36	7.02	...	14.34	...	...	1.06
Kan. City, St. Jo. & Council Bluffs	...	42	59,435	49,856	49,445	158,736	3,779	5.11	22.50	...	...	...	64.79	14.09	4.18	3.05	5.55	0.11	0.30	5.87	...	14.88	...	...	1.86
Lake Shore & Mich. Southern	592	575	430,477	769,072	641,294	1,840,843	3,184	...	...	60.88	83.61	31.28	60.89	...	...	2.78	4.65	0.17	...	6.94	0.18	14.67	...	...	1.52
Louisville & Nashville	...	†344	439,633	796,734	393,018	1,629,385	3,594	5.15	16.12	63.52	105.49	46.20	78.87	12.39	6.32	4.10	6.42	0.26	0.48	6.10	1.51	18.87	3.26	1.43	1.63
Manhattan Elevated	...	275	732,614	...	50,594	783,208	2,848	...	...	...	...	...	40.82	...	...	2.10	8.10	0.30	...	8.80	...	19.30	...	...	3.96
Mexican Central‡	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mil., L. S. & Western	112	...	80,381	167,945	114,690	363,016	3,241	...	...	...	...	...	69.37	...	...	.77	9.52	0.25	...	6.14	0.88	19.56	...	...	2.75
Minn., St. P. & Sault Ste. Marie	...	...	62,729	136,579	65,821	265,129	...	4.34	19.41	...	...	...	65.14	...	...	3.44	10.89	0.20	...	6.41	...	20.94	...	1.67	3.33
Missouri Pacific	339	311	...	...	...	1,211,122	3,894	4.52	18.29	...	...	...	84.64	14.43	6.04	4.95	6.12	0.36	1.32	6.64	1.32	20.71	4.71	1.26	1.42
N. O. & Northeastern	...	33	30,676	44,228	24,465	99,369	3,011	...	...	61.52	100.00	34.01	73.26	...	...	5.60	6.20	0.32	0.50	6.80	1.70	20.62	...	...	...
N. Y., Lake Erie & Western	...	621	464,466	993,637	301,004	1,759,107	2,833	4.80	23.40	87.60	122.70	65.60	...	18.20	5.30	4.44	6.93	0.40	2.29	7.20	1.06	22.32	...	1.54	1.34
N. Y., Pennsylvania & Ohio	...	255	135,104	435,336	136,121	706,561	2,771	5.90	18.30	76.40	126.20	71.30	...	13.00	6.90	4.68	6.07	0.30	2.46	6.91	1.01	21.43	...	1.73	1.15
Norfolk & Western, Gen. East. Div.*	...	145	100,854	271,296	55,126	427,276	2,947	4.80	19.90	...	...	...	96.62	...	...	7.30	3.10	0.70	...	...	...	11.10	...	...	...
General Western Division*	...	118	64,876	235,016	27,800	327,692	2,777	4.70	15.70	...	...	...	120.48	...	...	14.70	3.60	0.70	...	...	...	19.00	...	...	...
Ohio & Mississippi	119	...	148,312	149,151	93,168	390,631	3,283	...	...	...	...	...	69.68	...	...	2.85	3.09	0.22	1.30	5.42	1.31	14.19	...	...	0.86
Old Colony	...	227	366,001	128,749	124,666	619,416	2,729	...	...	...	...	...	58.22	...	...	3.19	10.92	0.63	...	6.55	0.75	22.04	...	...	3.75
Philadelphia & Reading	...	...	492,532	767,772	554,033	1,804,237	...	...	...	...	...	...	75.41	...	...	4.48	4.53	0.33	...	5.82	0.40	15.56	...	...	...
Southern Pacific, Pacific System	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Union Pacific	994	...	821,298	1,492,916	507,443	2,821,657	2,839	5.81	17.38	...	...	...	87.14	12.74	6.87	6.93	6.00	0.43	0.74	7.93	1.03	*25.06	4.05	1.82	1.63
Vicksburg, S. & P.	...	14	10,858	10,488	9,576	30,922	2,209	...	...	46.84	79.36	28.49	53.05	...	...	6.60	5.90	0.22	1.20	6.70	3.00	23.62	...	...	...
Wabash	406	357	418,442	799,885	372,261	1,585,588	4,199	5.19	18.02	69.23	104.99	55.34	84.00	13.34	5.33	3.23	4.71	0.29	...	6.39	0.77	15.39	2.64	0.97	1.12
Wisconsin Central	149	130	129,253	257,784	95,726	482,763	3,724	...	...	...	...	...	76.77	...	...	3.54	9.81	0.29	...	6.97	...	20.11	...	...	2.38
YEAR ENDING SEPTEMBER 30.																									
N. Y., Lake Erie & Western	...	618	5,375,183	12,092,424	3,598,133	21,065,690	34,087	4.70	21.70	87.80	127.70	68.50	...	18.80	5.90	4.82	6.09	0.41	2.21	7.17	1.10	21.80	...	1.80	1.33
N. Y. Pennsylvania & Ohio	...	261	1,701,366	5,263,202	1,692,072	8,656,640	33,167	5.40	17.90	75.70	124.70	70.30	...	14.00	7.00	4.36	6.34	0.31	2.34	6.72	1.02	21.09	...	1.77	1.20

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Wages of engineers and firemen not included in cost.

† Number of engines in revenue service only; average mileage is also based on revenue service.

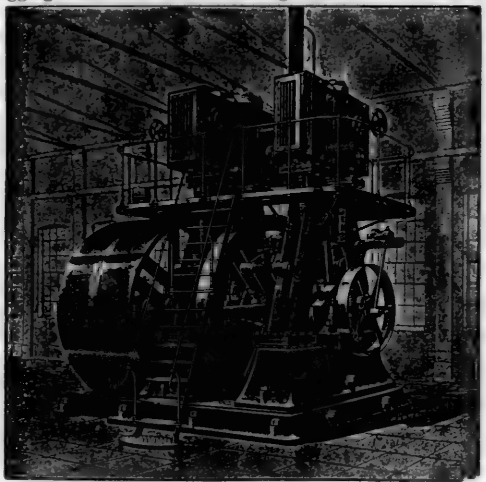
‡ The Mexican Central Railroad reports —— units of work per $1 of expense; —— units of work per ton of coal; —— lbs. of coal per unit of work. The unit of work is 100 gross tons hauled one mile in one hour on a straight and level track.

structure of iron, to which direct coupled generators may be firmly secured.

The piston speed is kept uniform in all sizes of engines, being 650 ft. per minute, the rotative speed varying from 80 revolutions on a 2,000 H.P. triple to 246 revolutions per minute on a 100-H.P. compound, thus allowing the engine to be connected direct to generators.

The cylinders are of the four-valve type, having two ports for steam and two ports for exhaust, with a steam-chest on one side and an exhaust-chest diametrically opposite on the other side, standing at right angles with the crank-shaft, and allowing perfect freedom of access. The clearances are from 2½ to 7 or 8 per cent., according to the diameter of the piston, being least on the greater diameters, and modified somewhat by the pressures of steam, higher pressures requiring larger port areas and larger clearances.

The cylinders are substantially and neatly lagged with iron, and the intervening spaces between the cylinders and lagging filled with non-conducting material. The steam-



VERTICAL COMPOUND ENGINE.

chest covers are provided with hoods, paneled and polished on the exterior surface. The valves are small, light and four ported, the high-pressure steam valve being perfectly balanced and the others working under light pressures on their seats. The steam and exhaust valves are worked by independent gear and the lap is adjustable, permitting of the most advantageous setting for either condensing or non-condensing service. The governor and steam valves are constructed to carry the steam as far as seven-eighths stroke in the first cylinders should the demands of the load at any time require it, permitting the engine to exert not less than 30 per cent. more power than any engine with releasing valve gear of same diameter of cylinders and piston speed. This feature specially qualifies the engine for railroad and other work requiring high powers through short periods of time.

In most marine engines using piston valves in the high-pressure cylinder, the diameter of the valve-chest is often as large, if not larger, than that of the high-pressure cylinder itself. In a triple-expansion engine, and with the same style of valve used on the low pressure, it becomes necessary to use two and sometimes three different valves, having their centers on a circle whose center is coincident with that of the low-pressure cylinder.

The movement of the high-pressure admission valve is controlled in these engines by the centrifugal shaft governor, by which means the engine is regulated as regards speed of revolution. This point is of course a very important one in this class of work, and in this governor, which has only one weight, one spring and four pivoted joints, the sensitiveness is very great, as is shown by the variation of speed of the engine in regular work, which does not exceed 1 per cent. under extreme changes of load, and is not over 2½ per cent. when two-thirds of the rated load of the engine is thrown off or on. Some objections have been raised to the advisability of governing an engine of large powers—say 500 H.P. and upward—by means of a shaft governor. The fact that these engines are running to-day successfully on this class of work and under the above regulation meets this argument conclusively.

The makers have given much care to the details of construction. For instance, the piston-rod and cross-head are forged in one piece, and babbitted slippers fastened to the head of the rod, set out, not by wedges, but by liners only. The connecting rod is forged and of the forked pattern, having the wrist-pin secured firmly in the ends of the fork, and a central bearing in the cross-head. The crank end has a two-part box independent of the rod forging, with through bolts.

Another very important consideration, and too often overlooked, is that of main bearings. The pressure per square inch of projected area and the surface velocities are often so near the limit that, when any slight overload comes on the engine, heating occurs immediately. Special attention has been given to this point, and the main bearings are so proportioned that the pressures and the velocity of the rubbing surfaces are uniform in all engines, whether the engines be simple, compound, triple or quadruple, and the service is within the limits of remarkable durability and ease of management; bearings being supplied with appliances for grease or oil lubrication as desired. All wearing surfaces on the larger size engines are water-jacketed.

As regards the economy, it can be readily seen from the steam distribution effected by means of the valve gear described on this engine, that the economy shown should be equal to that of a Corliss. The cylinder condensation is low, the clearances are small and the steam distribution through the cylinders is nearly perfect. The engines are built in all types and sizes, in simple, compounds, triples and quadruple expansion, up to 8,000 H.P. units. No expense has been spared to make this engine fit the exact requirements of the service, and this is the first engine, probably, that has ever been designed under these conditions for general commercial sale.

Further information can be obtained from the Field Engineering Company, 143 Liberty Street, New York.

Foreign Naval Notes.

THE armored coast-defense ship *La Libertad*, just completed by Laird Brothers at Birkenhead, England, for the Argentine Navy, has had her speed trials, making an average speed of 13.35 knots with natural draft and 14.32 knots with forced draft. *La Libertad* is a twin-screw steel ship 240 ft. long, 44.4 ft. beam, 13 ft. draft and 2,300 tons displacement. She has a water-line armor belt, a heavy protective deck; two armored barbettes and a central breastwork. Each screw is driven by a triple-expansion engine with cylinders 21 in., 31½ in. and 46 in. × 24 in.; on the trial they worked up to 2,900 H.P., with 145 lbs. steam pressure. The armament includes two 9.5-in. Krupp guns; four 4.7-in. Armstrong rapid-fire guns; four 3-pdr. Maxim guns and four machine guns; there are also four torpedo-tubes.

THE new Russian cruiser *Rurik* was successfully launched from the yard of the Baltic Shipbuilding & Machine Works, at St. Petersburg, November 3, with appropriate ceremonies, the Imperial Family and a large number of officers and invited guests being present. The *Rurik* is a first-class cruiser, the largest yet built in Russia; her construction was begun in August, 1890, and the engines are not yet quite ready. The general dimensions are: Length, 435 ft; breadth, 67 ft.; mean draft, 25 ft. 9 in.; displacement, 10,933 tons.

The hull was built by the Baltic Works, the steel being furnished by the Putiloff Works of St. Petersburg, and the armor-plates by the Naval Works at Izhora, near St. Petersburg. The hull is sheathed up to the water-line with double planking covered with copper. In building the hull there were used 3,060 tons of steel and 28 tons of copper, besides 100 tons of bronze for the rudder, the shaft bearings, stem and stern castings and such work. The wood used in construction was fir for the inner layer of hull sheathing and for deck planking; larch for the outer layer of sheathing and for backing for the armor plates.

The *Rurik* will have four triple-expansion engines, two to each screw. They are now under construction at the Baltic Works, and are expected to develop 12,250 H.P. The coal

storage capacity will be sufficient to carry the ship from St. Petersburg to Vladivostok without calling at any port.

The armament will consist of four long-range 8-in. guns; sixteen 6-in. rapid-fire guns of the latest pattern; six 4.7-in. rapid-fire guns; sixteen 47-mm. and 37-mm. rapid-fire guns; two Baranovski machine guns; and six torpedo-tubes.

Next year the building of a still larger cruiser will be begun.

Manufactures.

A Modern Boiler Plant.

The illustrations given below show a steam plant designed and constructed for Curtis Davis & Company, Cambridgeport, Mass., by Westinghouse, Church, Kerr & Company, of Boston; the detail work being carried out by William R. Roney, the Engineer of their stoker department. *Carte blanche* was given the engineers to design a boiler house to contain every practical element of economy which could bear upon the sum total of the cost of making steam; they being limited only to the horizontal return-tubular type of boiler by certain considerations outside of economy.

In the carrying out of this work the ornamental side of the problem was not forgotten, and the architectural design of the boiler house was prepared by Hartwell & Richardson, of Boston. It is worthy of emphasis that the owners of this plant have set a creditable example to manufacturers in general in providing a building which shall not only be adapted to the matter-of-fact work to be done in it, but shall present a fitting and dignified appearance. The building is of pressed brick with trimmings of pink Milford granite. The roof is of iron trusses, covered with slate and lined on the inside with wire lath and plaster, for the purpose of preventing condensation. The fire-room floor is of concrete. An annex to the building contains a scale-room for tallying the weight of coal, and a complete wash-room for the fireman, who has now become a gentleman of leisure.

Passing to the operative portion of the plant, it will, when completed, consist of eight horizontal return-tubular boilers of 125 nominal H.P. each, to carry a working pressure of 130 lbs. These boilers are arranged in two batteries of four each in either end of the building (one battery is now in operation), the space between being utilized as a pump-room. Following the progress of the coal, after it is weighed it is dumped on a grating at the end of the boiler house, shown in the general

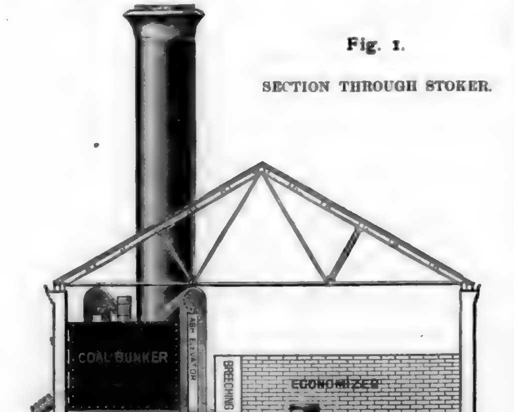


Fig. 1.

SECTION THROUGH STOKER.

view. The large lumps are easily broken by the teamster, the grating serving as a screen to reduce the coal to a uniform maximum size. From the grating the coal falls into a bucket elevator carrying it to an overhead conveyer extending the entire length of the boiler house, from which it distributes into square iron bunkers having hopper bottoms. The bunkers are supported on iron girders in front of and above the boilers. From the bunkers the coal flows by gravity through swivel spouts to the hoppers of the stokers.

Each boiler is equipped with a Roney mechanical stoker, which furnishes a continuous supply of coal to the furnace at a slow rate of feed; the quantity of coal and its distribution being regulated at will by hand-wheel adjustments on the traverse motion. The power to operate the entire battery of stokers is a small engine carried on a bracket at one end of each battery, and driving a slow-moving eccentric shaft.

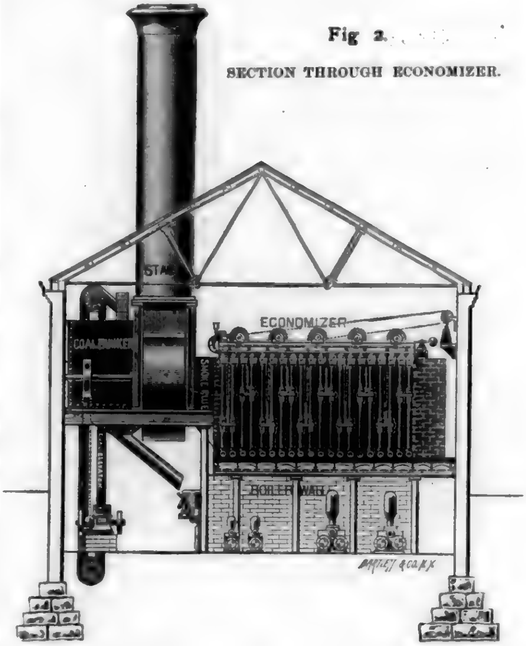


Fig. 2.

SECTION THROUGH ECONOMIZER.

The action of the stoker is first to liberate the free gases and partially coke the coal on a dead plate underneath the coking arch, in connection with an indraft of hot air through perforated channels in the firebrick tile. This portion of the device constitutes a strictly smokeless furnace, the result being obtained, not by *concealing* or *consuming* the smoke, but by actually *preventing* it by complete combustion from the start. In this is a large portion of the economy due to mechanical stoking, to say nothing of the extermination of the smoke nuisance. After leaving the coking arch the coal is slowly worked down over the rocking grates into the hottest portion of the fire, and when consumed, the ash and cinder falling on the dumping grates is dropped into the ash-pit. From the ash-pit the ashes fall into a screw conveyer, which carries them to one end of the building where they are elevated into an ash-bin and discharged as required through a spout into carts for removal. Thus, from the time the coal is first dumped by the teamster until the ashes are in the cart, there is practically no manual labor employed, and the duties of the fireman reduced essentially to watchfulness and supervision only. One man constitutes the force of firemen and runs the entire plant.

A most interesting portion of the plant is the means of securing controllable draft. The usual expensive chimney stack is conspicuous by its absence, and in its place will be found a steel stack 72 in. in diameter, extending 17 ft. above the ridge of the roof and showing a total height to the top of about 55 ft. above the ground. This stack is lined with one course of brick merely to prevent rust, and is finished with ornamental top. The stack having no functions, so far as the production of draft is concerned, is only of a length sufficient to deliver

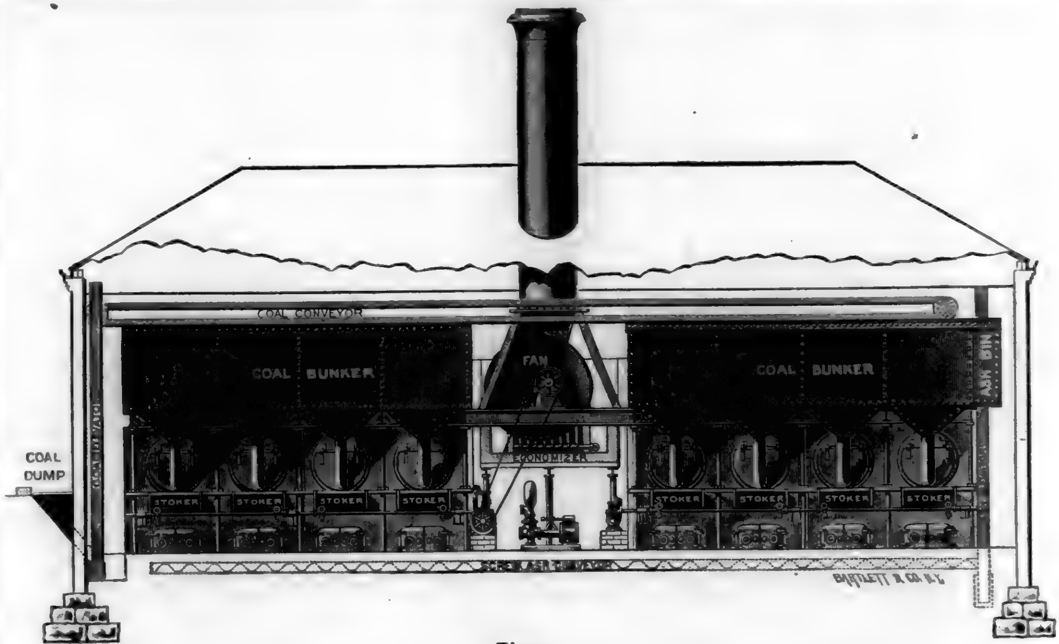


Fig. 3.
ELEVATION OF PLANT.

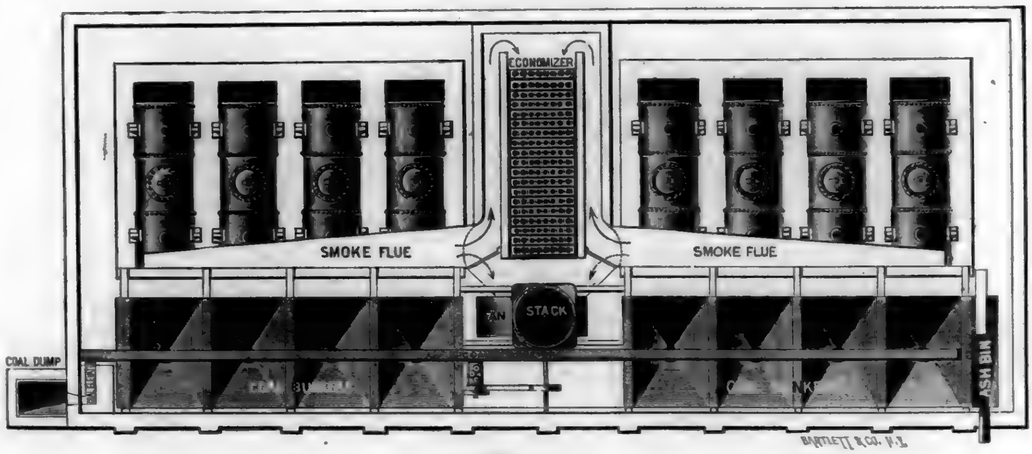


Fig. 4.
PLAN OF BOILER ROOM.

the gases above the roof. The stack is supported on an entablature, which in turn is carried on I-beams over the boiler room. On these I-beams is a large slow-running exhaust fan, whose outlet discharges directly up into the bottom of the stack. The waste gases from the furnace pass through a Lowcock economizer, which opens into the suction of the fan. The economizer is carried on iron columns, and the whole system is therefore overhead and out of the way, leaving a clear floor space below. A by-pass damper is provided on each side of the economizer, so that the draft can be direct to the stack in case the economizer is temporarily out of service for repairs. A steam-cone nozzle may be set in the base of the stack as a relay in the remote contingency of any necessity for overhauling the fan. The probability of repairs is best judged by the fact that the usual speed of the fan in ordinary service is from 40 to 50 turns per minute, and when driven at the slow speed of 80 turns per minute it is sufficient to cause a draft adequate to the most intense combustion. The motive power of the fan is a small Westinghouse engine, nominally of 10 H.P., but in fact running at so slow a speed and under such a close throttle as to develop only a fraction of that power. The draft is automatically controlled by a pressure regulator in the steam pipe to the engine, so that the speed of the fan is varied according to the steam pressure in the boilers, being in this respect the equivalent of the most sensitive steam damper. This scheme of mechanical draft is capable of producing a draft pressure equal to that of a 200 ft. chimney costing ten times as much to build, and additionally possesses the feature which no natural draft enjoys, of absolute flexibility in meeting sudden demands of steam. The fireman is thus rendered independent of weather conditions, and has nothing to fear from a dirty fire after a long run, or from any of the emergen-

cies which may throw an excessive duty upon his boiler plant without warning. He has the fire at all times wholly within his control, while at the same time the regular service is performed under the most perfect automatic regulation.

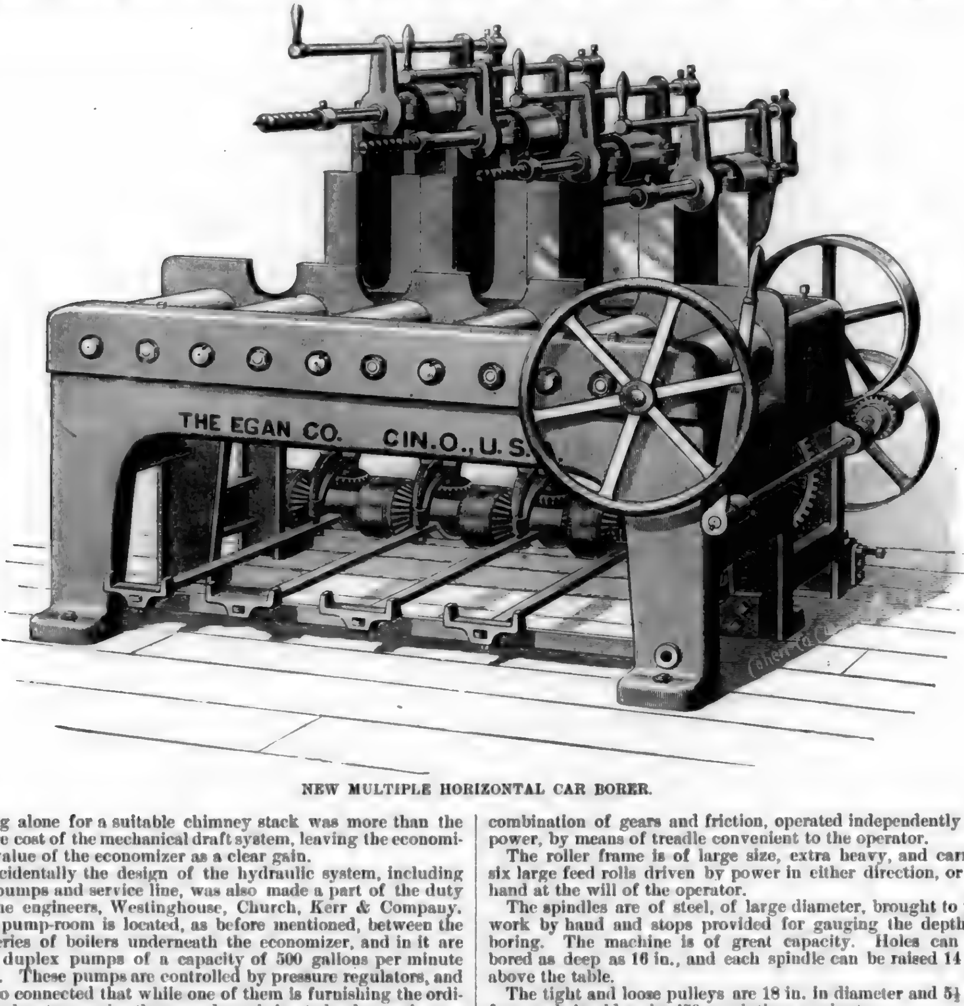
The action of the economizer is, of course, to extract all the available heat from the waste gases and return them into the boiler. The temperature of the up-take is about 100°, the temperature of the feed water leaving the economizer being upward of 300°, and representing an amount of heat saved which would otherwise be wasted up the stack as the only means of producing a natural draft. A moment's reflection will show the comparative value of the heat thus returned to the boiler, as against the insignificant amount of steam required to run the slow-moving fan. The mechanical exhaust draft in this case was not a part of the original scheme, but was finally adopted when it was discovered that the cost of the piling alone for a suitable chimney stack was more than the entire cost of the mechanical draft system, leaving the economical value of the economizer as a clear gain.

Incidentally the design of the hydraulic system, including the pumps and service line, was also made a part of the duty of the engineers, Westinghouse, Church, Kerr & Company. The pump-room is located, as before mentioned, between the batteries of boilers underneath the economizer, and in it are two duplex pumps of a capacity of 500 gallons per minute each. These pumps are controlled by pressure regulators, and are so connected that while one of them is furnishing the ordinary elevator service the second one is kept slowly moving, so as to be in condition for instantaneous fire service. The work of these pumps is alternated daily, and in case of fire both can be concentrated immediately on the fire lines. In the same pump-room are double boiler-feed pumps, each one adequate to the entire capacity of the plant. All the hot-water lines and fittings are of brass, and by-passes are provided so that the feed water can be pumped through the economizer, or direct to the boilers in case of repairs to the latter. A further system of a water meter with by-pass valves is so arranged that the feed water can be measured and pumped to either boiler independently, or to any number of boilers, or to the entire battery, at will. With a water meter in the feed line and a pair of scales at the gate, it is proposed that the condition of the entire plant, as to its evaporative duty, shall be daily logged and reported to the office, and any decline of efficiency thereby promptly and practically detected.

A New Horizontal Car Borer.

THE accompanying illustration shows a new multiple horizontal car borer, one of the most useful and powerful machines made for rapid and heavy boring. It is especially adapted for car and bridge work.

The column is one heavy casting, planed perfectly true for the mandrel frames to raise and lower in, keeping them perfectly rigid. Each mandrel frame is raised and lowered by a combination of gears and friction, operated independently by power, by means of treadle convenient to the operator.



NEW MULTIPLE HORIZONTAL CAR BORER.

The roller frame is of large size, extra heavy, and carries six large feed rolls driven by power in either direction, or by hand at the will of the operator.

The spindles are of steel, of large diameter, brought to the work by hand and stops provided for gauging the depth of boring. The machine is of great capacity. Holes can be bored as deep as 16 in., and each spindle can be raised 14 in. above the table.

The tight and loose pulleys are 18 in. in diameter and 5½ in. face, and should make 450 revolutions a minute.

This machine is a new one just added to the extensive list of the makers, the Egan Company, Nos. 194–214 West Front Street, Cincinnati, O.

Paint for Lighthouses.

THE firm of W. W. Lawrence & Company, in Pittsburgh, recently filled an order from the United States Government for nearly 10,000 galls. of paint, which is to be used on the lighthouses and Government buildings on the Atlantic Coast

from Maine to Florida. The exposure to the winds and salt air of the sea-coast is very severe on paints, and very few will stand the test. Two years since this firm filled a similar order, which indicates that its paint has fully satisfied the strict requirements of the Government service.

A New Water-Tube Boiler.

THE accompanying illustrations show a new form of sectional water-tube boiler made by the New York Safety Steampower Company, and known as the Worthington boiler. Fig. 1 shows this new boiler complete, and fig. 2 with the casing removed. It belongs to the sectional class, in which the water is contained in small tubes and chambers, designed to secure the important requisites of safety, durability, accessibility and high evaporative efficiency, and is designed to be economical of valuable space and at the same time to be of liberal proportions in grate area and heating surface. The interior of the entire construction, in every part and detail, is accessible from the outside for examination, cleaning or repair. The furnace extends under the entire boiler and is of proper height to permit the use of any kind of fuel. As will be noted, the tubes are arranged in transversely inclined series of several tubes per section.

The heating surfaces and waterways are so arranged that the movement of the water contained in the boiler is constant and rapid. Its course is as follows: From the steam-and-water drum located above the tubes, into which water is fed, it descends the water legs, four in number, placed outside the furnace, to the water-and-mud drums, at the base; thence it passes *viâ* the tube connections into the lower series of headers; thence through the tubes, over the fire, into the upper series of headers; thence *viâ* the tube connections into the steam and water drum again (from whence it started). The proportion and combination of parts throughout the boiler is such that expansion and contraction due to changing temperatures can occur without straining or disturbing the position of any part or system of parts.

The tubes being short, tubular expansion is reduced to a small fraction, as compared to that which is due to the employment of tubes of 16 to 20 ft. long.

The headers for tubes are made of steel or iron, according to the service required. They are placed closely together side by side, forming complete side walls to the furnace and affording a limited amount of effective heating surface.

Outside the furnace, opposite each end of each tube, a handhole of proper size to admit a tube or a tube expander is provided and fitted with a cap held to place with a cross-bar and bolt. This cap is accurately faced and ground to a perfect steam and water-tight joint. The caps are exposed upon opening the side doors, and can be examined or tightened if necessary. Upon removal of the cap, the internal condition of a tube is open to inspection, to cleaning, or, in case of leakage in the expanded joint, to re-expansion. And in case of accident to a tube or depreciation due to long usage, a new tube can be substituted with but little trouble and delay. Each end of each mud drum is provided with a removable cap accessible from outside.

The furnace is lined with fire-brick. The only other brick work required to erect a stationary boiler consists of two foundation walls of proper depth, rising above floor level about 12 in.

These boilers are proportioned and rated for generating power on the basis of the Centennial standard—namely, the evaporation of 30 lbs. of water, at 70 lbs. pressure, from temperature of 100°, to be 1 H.P. Said duty to be accomplished with a consumption of anthracite coal of good quality at the rate of 12 lbs. per hour per square foot of grate with good natural draft. It is claimed that the actual steaming efficiency and also the ultimate capacity are largely in excess of the rating on the above basis. A 100 H.P. boiler of this kind occupies a floor space 7½ ft. square, and is less than 10 ft. high.

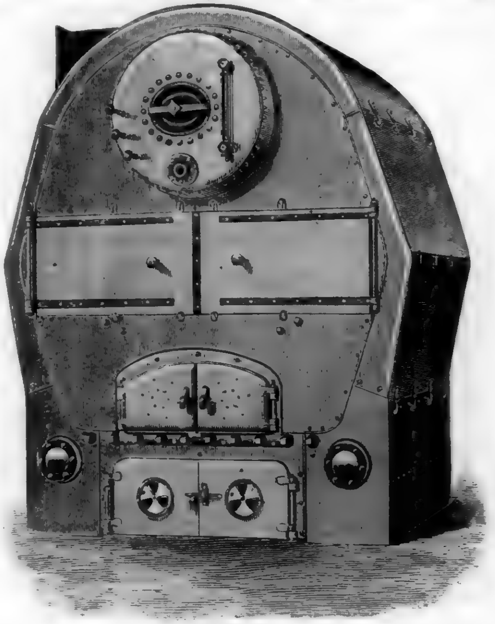


Fig. 1.

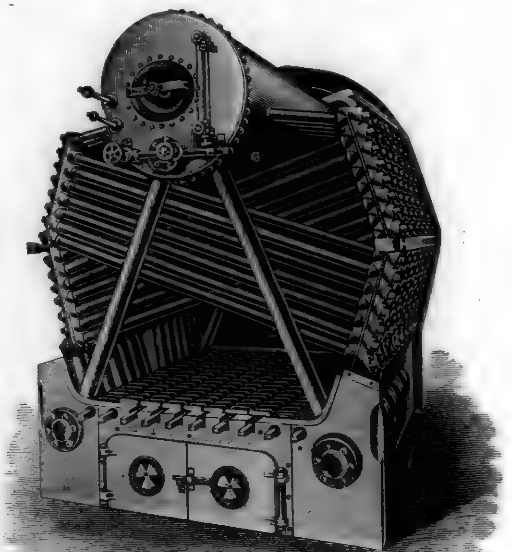


Fig. 2.

THE WORTHINGTON SAFETY WATER-TUBE BOILER.

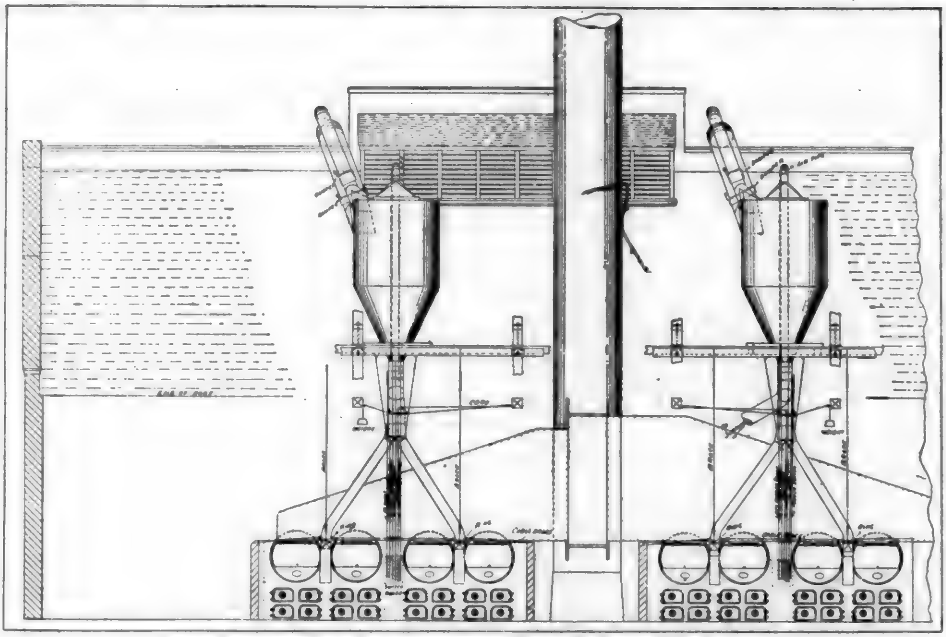
A Free Technical School.

IN the educational department of the Young Men's Institute, of the Young Men's Christian Association of the City of New York, at 222 and 224 Bowery, much attention is given to technical studies, and the work is becoming more and more valuable to young mechanics and artisans. The evening classes in Electricity, Steam Engineering, Carriage Drafting, Mechanical Drawing, Freehand Drawing, Shorthand and Type-writing, Vocal Music, Arithmetic, Book-keeping and English Grammar have an enrollment of almost 300 young men. A free exhibition of work done in the classes was given on December 26, making an interesting showing of progress.

The Institute Committee of Management and the Carriage Builders' National Association award diplomas, prizes, and certificates of progress at the close of each class year.

An Appliance for Wood-Working Shops.

One of the problems requiring careful attention in a wood-working shop is the disposal of the sawdust, which would accumulate in large quantities if not carried off as it is made. An excellent method of meeting this problem is shown in the accompanying cut, which is from a drawing of a dust-collector and furnace feeder made by the United States Blow-Pipe Company, of Chicago, for the extensive car shops of the Madison Car Company, at Madison, Ill. The drawing shows the general arrangement of the shops and the apparatus.



DUST-COLLECTOR AND FURNACE-FEEDER AT THE MADISON CAR WORKS.

The dust-collector and furnace-feeder itself, as shown, is the smallest part of the apparatus. The shop is equipped with galvanized steel piping and exhaust fans, by which the dust and shavings from the machines are collected and carried to the dust-collector, which feeds them directly to the boiler furnaces without the interposition of any manual labor whatever. Should more fuel be made than the furnaces can properly consume, a slight change will direct the surplus into a vault made for its reception, and in this way the fires can be regulated and choking of the furnaces avoided.

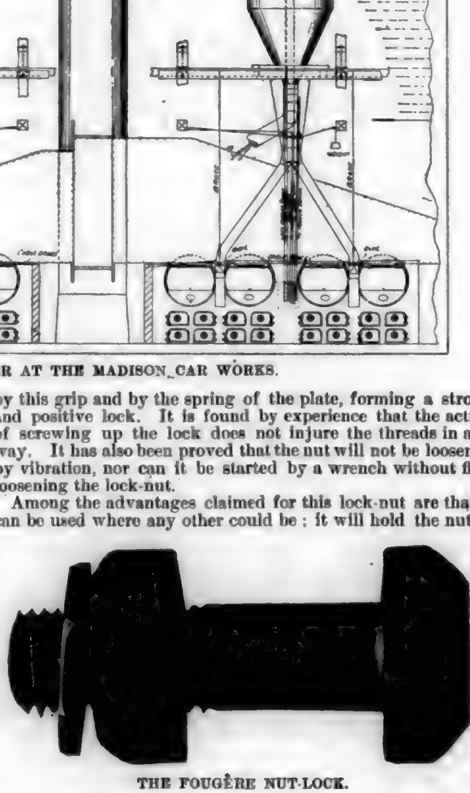
By experience with this apparatus, it is found that the regulation is an important point, giving an even and steady fire and keeping steam at any desired point. Economy in fuel is also secured, as well as a great saving in labor. In fact, the company claims that the cost of its apparatus in a large shop will be repaid in two or three years from the saving in labor alone. The apparatus has worked satisfactorily wherever tried.

The address of the United States Blow-Pipe Company is No. 16 South Canal Street, Chicago, and estimates can be furnished for fitting up shops of any size and capacity.

The Fougère Nut-Lock.

This nut-lock, which is shown in the accompanying illustration, is certainly simple in form and appears to have some excellent points. The lock is about the size of an ordinary washer, and is hexagonal in form. It is cut from a thin plate of mild steel proportioned in size and thickness to the bolt on which it is to be used. A thread is then cut in it obliquely, the angle of the lock nut to the cutting tool being from 3° to 8°, according to the size of the bolt. The lock-nut when screwed on the bolt assumes an oblique position thereto, so that when it is screwed down lightly until it reaches the nut or other resisting surface, one side bears and the other does not. If now it is forced with the wrench, the lock yields, and is gradually forced down squarely on the nut and lies flat on top of it. In this position it exerts a strong frictional contact with the top of the nut, and the thread in the lock being forced from its natural position, tends to cross the thread on the bolt, and the two threads thus grip each other. The lock is thus held by this grip and by the spring of the plate, forming a strong and positive lock. It is found by experience that the action of screwing up the lock does not injure the threads in any way. It has also been proved that the nut will not be loosened by vibration, nor can it be started by a wrench without first loosening the lock-nut.

Among the advantages claimed for this lock-nut are that it can be used where any other could be; it will hold the nut at any point on the bolt, whether it is screwed up tight or not; it can be used again and again without injury to itself or the bolt, and it forms a neat finish.



THE FOUGÈRE NUT-LOCK.

This nut-lock is protected by patent No. 465,094, issued to Angus Fougère. Any information in relation to it can be obtained from R. H. Cushing, of Moncton, N. B.

Some 25,000 of the locks are in use on the Intercolonial Railway of Canada, where they have been thoroughly tested for over a year on track-bolts, locomotive tender frames and other positions.

Plans have been completed for a large depot to be built by the Baltimore & Ohio Company, at St. George, Staten Island. The plans were prepared by Baldwin & Pennington, who have made duplicate copies for the use of the railroad officials. Bids for this work will be asked for in a few days.

General Notes.

THE Safety Metallic Tie Company has been organized at Summit, N. J., with $500,000 capital stock, to make metallic ties and rail fastenings.

THE Pennsylvania Steel Refining Company has bought the old works of the Bates Steel Company, in Philadelphia, and will put them in operation, using the Reedman-Tilton process for refining and hardening steel. Mr. Walter J. Scott, late of New Albany, Ind., will be Superintendent.

THE Hyatt Roller Bearing Company has been organized in Newark, N. J., to make roller bearings for car journals and other purposes.

THE Gilbert Car Company, Troy, N. Y., has taken a contract to build 30 baggage cars, 10 combination cars, 20 smoking cars, 50 passengers cars and 20 passenger cars with vestibule ends for the New York Central & Hudson River Railroad.

THE Richmond Locomotive Works, Richmond, Va., recently completed an order of 30 freight engines for the Cleveland, Cincinnati, Chicago & St. Louis Railroad.

THE Weisel & Vietor Machine Company, whose works were destroyed in the recent great fire in Milwaukee, Wis., will rebuild them on a larger scale.

THE Schoen pressed steel brake-beam is to be used on 600 cars now building for the Duluth, Mesaba & Northern Railroad. These cars will also have Schoen pressed steel center-plates.

THE Roanoke Machine Works, Roanoke, Va., are building a number of locomotives for the Norfolk & Western Railroad.

THE shops of William Sellers & Company, Philadelphia, are building for the Massachusetts Institute of Technology a 300,000 lbs. Emery testing machine. This machine will be equipped with all the latest and most improved recording apparatus, and will have embodied in its construction some details that are not found in any other machines of its class. It is strictly a tensile machine, being horizontal, but compression tests could be made by the use of special appliances.

THE Frank-Kneeland Machine Company, recently organized in Pittsburgh with L. W. Frank as President and Edward Kneeland as Treasurer, is building a foundry and machine shop which will be thoroughly equipped with tools and machinery for doing the best work.

THE Stillwell-Bierce & Smith-Vaile Company, of Dayton, O., was recently formed by the consolidation of the Stillwell & Bierce and the Smith & Vaile companies. The new company is capitalized at $1,000,000, and $500,000 preferred stock offered for public subscription was promptly taken up. The company owns extensive works for the manufacture of turbines and other machinery.

THE offices of William C. Baker, the well-known manufacturer of car-heaters, has been removed to the Central Building, No. 143 Liberty Street, New York. Mr. Baker has established new works in Hoboken, N. J., which are fitted with the best appliances for manufacturing.

THE Akron Tool Company, Akron, O., has recently received orders for their McNeil patent balanced charging barrows from the Boston & Maine, the Georgia Southern & Florida and the Alabama Midland railroads. These barrows have found much favor in use at coaling stations on railroads, and are also in use at many gas works for handling hot coke and at blast furnaces for charging with coke and ore. Their use is rapidly extending.

THE Congdon Brake Shoe Company has established a plant for the manufacture of steel brake-shoes and couplers at 59th Street and Wallace Avenue, in Chicago. The works cover 2½ acres, and include a Siemens-Martin open-hearth steel plant with a capacity of 35 to 40 tons per day. Facilities are provided for making all kinds of steel castings here, as well as those required for the brake-shoe and coupler work, and arrangements have been made for turning out castings of a high grade, for locomotives and other machinery. Two large dynamos supply electricity for lighting the works and for running the Shaw electric cranes. These works will use oil for fuel; it is delivered in the works from the Pennsylvania Company's tracks.

AT a recent meeting of the directors of the Consolidated Car Heating Company, Albany, N. Y., a semi-annual dividend of 1½ per cent. was declared. The reports showed that the business of the company has averaged over $1,000 per day for some time past.

At the same meeting the offices of General Manager, Assistant General Manager and Mechanical Superintendent of the Company were abolished. Mr. D. D. Sewall, formerly General Manager, was appointed Vice-President; Mr. J. H. Sewall, former Assistant General Manager, with office in Chicago, was made Superintendent of Construction, with office in Albany; and Mr. J. F. McElroy, late Mechanical Superintendent, was appointed Consulting Engineer.

THE Walburn-Swenson Company, owning the Fort Scott Foundry & Machine Works at Fort Scott, Kan., is now removing the entire plant to Chicago Heights, as a more central and convenient location for its special business. The central office of the company has been established in the Monadnock Block.

THE Dietz Passenger Draw-Bar Company and the Dietz Freight Draw-Bar Company have been organized in Denver, Col., each with a capital stock of $500,000, to manufacture and introduce the Dietz draw-bars, which have been heretofore described in our columns. The officers of both companies are: President, Edward A. Reser; Vice-President and General Manager, Thomas C. Brainard; Secretary and Mechanical Expert, Henry Dietz; Treasurer, Henry B. Adsit.

THE largest single order for car-heating material ever given was received by the Consolidated Car-Heating Company, on December 15. This order was for the equipment of 100 New York Central standard coaches, which the Gilbert Car Manufacturing Company is building.

THE Schenectady Locomotive Works have received an order for 16 locomotives for the Chicago & Eastern Illinois, and three freight engines for the Maine Central. All are to be equipped with the New York air brakes.

THE Buffalo, Rochester & Pittsburgh Railroad is just receiving the last of the recent order for 850 cars, all equipped with the New York air brake.

THE Joseph Dixon Crucible Company, of Jersey City, manufacturers of Dixon's American Graphite pencils, are taking time by the forelock by putting a fifth story, 175 × 75 ft., on their pencil factory. During the past summer and fall they have been unable to promptly fill their orders for Dixon's pencils, even though working their already superior facilities to their full capacity. It was therefore decided to push forward the work at once instead of waiting until spring, as intended. The new addition will be equipped with new and improved pencil machinery of their own invention.

THE Lansberg Brake Company, St. Louis, recently received an order for 2,800 complete quick-action freight car brakes. The company's works are to be enlarged.

Forged Steel Balls.

THE Pittsburgh Steel Casting Company is now making steel balls by a special process, which is new and gives very good results. This company makes steel castings, and has lately found that cast-steel balls, forged, were susceptible of many industrial applications, and accordingly made preparations for their manufacture.

The balls are first cast as an ordinary casting, of a special crucible steel mixture, especially adapted for the purpose, which is somewhat more expensive than the mixture used for ordinary castings. The cast ball is brought to a forging heat in an ordinary heating furnace, and transferred to a 1-ton steam hammer, provided with hemispherical dies the size of the casting. While this hammer is rather heavy for the smaller-sized balls, its stroke can be made light enough to suit. The hammer being started at a rate of about 120 strokes per minute, the ball is dexterously rotated in different directions by the hammer-man, so that it is very evenly compressed, and all signs of the head and gate obliterated, a perfectly spherical ball being the result, while toward the latter end of the process a smooth polish may be seen to come. From time to time water is thrown on, and when the forging operation is completed, the ball is allowed to cool rapidly, so that the surface takes quite a good temper, and is excessively hard. The ball is compressed by about $\frac{1}{16}$ of its diameter.

These balls have probably not as yet been used for all the purposes for which they are adapted, but we are informed that they are used extensively for crushing purposes, for emery, black lead, corundum, rouge, etc. They are used also for ball bearings in turn-tables, etc.

Dies are provided for all sizes of balls, from 2 in. to 9 in. in diameter. The expense of forging, and of the extra mixture employed, makes these balls cost about 2 cents a pound more than an ordinary steel casting.—*American Manufacturer*

PERSONALS.

A. T. SHOEMAKER has removed his office in New York to the Boreel Building, No. 115 Broadway.

JOHN MEDWAY has been appointed Superintendent of Motive Power of the Fitchburg Railroad, with office in Boston, in place of O. STEWART, who has resigned.

DAVID POTTINGER, late General Superintendent of the Intercolonial, succeeds MR. COLLINGWOOD SCHRIEBER as Chief Engineer of Canadian Government railroads.

J. J. R. CROES delivered an interesting lecture on Passenger Traffic in Large Cities before the students of the Rensselaer Polytechnic Institute in Troy, N. Y., on November 30.

CAPTAIN ALFRED E. HUNT, President of the Pittsburgh Reduction Company, lectured on Aluminum recently before the students of the Rensselaer Polytechnic Institute.

W. I. COOK has been appointed Superintendent of Motive Power of the Toledo, St. Louis & Kansas City Railroad, in place of JOHN ORTTON, who has resigned on account of continued ill health.

HUNTER McDONALD, for some time past in charge of the construction of new branches, has been appointed Chief Engineer of the Nashville, Chattanooga & St. Louis Railroad, to succeed the late COLONEL R. C. MORRIS.

HENRY A. MILLHOLLAND, formerly with the Pennsylvania Railroad, and more recently Mechanical Engineer of the Gould Coupler Company, has been appointed Assistant to the Superintendent of Motive Power of the Philadelphia & Reading Railroad.

F. W. SARGENT, formerly Engineer of Tests of the Chicago, Burlington & Quincy Railroad and recently General Agent of the Congdon Brake Shoe Company of Chicago, has been appointed Superintendent in charge of that company's manufacturing department.

JACOB JOHANN has been appointed Superintendent of Motive Power of the Chicago & Alton Railroad, with office in Bloomington, Ill., in place of A. W. QUACKENBUSH, resigned. Mr. Johann is well known as a master mechanic of long experience, who has had charge of the machinery of some important roads.

THEODORE VOORHEES, General Superintendent of the New York Central & Hudson River Railroad, delivered a lecture on Transportation before the students of the Rensselaer Polytechnic Institute at Troy, N. Y., December 7. Mr. Voorhees is a graduate of the Institute, and is also a member of its Board of Trustees.

THE friends of MR. JOHN ORTTON will be grieved to hear of his serious illness. For a long time he has been in poor health, but recently he has been a great sufferer, although the latest accounts report his condition somewhat more favorable for recovery. He is now at Frankfort, Ind., having resigned his position as Superintendent of Machinery on the Toledo, St. Louis & Kansas City Railroad.

AUGUSTUS MORDECAI, who succeeds MR. C. W. BUCHHOLZ as Chief Engineer of the New York, Lake Erie & Western Railroad, has been since 1888 General Roadmaster of the New York, Pennsylvania & Ohio. He had previously served as Division Engineer on that road, and also on the Pittsburgh, Virginia & Charleston, the St. Louis, Council Bluffs & Omaha, the Hartford & Connecticut Western and the Pennsylvania Railroad.

OBITUARIES.

JOSEPH N. DUBARRY, who died in Philadelphia, December 17, aged 62 years, was born in Bordentown, N. J., and when 18 years old was employed on one of the engineer corps engaged in locating the Pennsylvania Railroad from Altoona to Pittsburgh. In 1850 he was made Assistant Engineer of Construction, and in 1852 had charge of surveys on the old Sunbury & Erie Railroad. In 1853 he was made Principal Assistant Engineer of the Southwest Branch of the Pacific Railroad of Missouri, and remained on that line five years, when he returned East as Superintendent and Engineer of the Western Division of the Pittsburgh, Fort Wayne & Chicago. In 1861 he became General Superintendent of the Northern Central Railroad, where he remained until 1867, when he was appointed to the position of Assistant to the President of the Pennsylvania Railroad Company, which he filled with marked ability until October, 1882, when he was made Third Vice-President. His duties then were those of General Supervisor of Constructions, having charge of the construction of new lines, of bridges, viaducts, tunnels, of straightening curves, and the determination of all engineering questions. In 1888 Mr. DuBarry was elected Second Vice-President to take the place of Mr. Frank Thomson, who had been elected First Vice-President, and he occupied that important office in the company's affairs up to the time of his death. In this capacity his duties embraced a general supervision of all financial affairs and a direct oversight of the treasury and insurance departments. He was also the master mind in the promotion and construction of new lines of road and the maintenance of the old lines to the highest standard.

PROFESSOR JOHN STOREY NEWBERRY, who died in New Haven, Conn., December 7, aged 70 years, was born in Windsor, Conn., but at an early age was taken to Ohio by his parents. He graduated from the Western Reserve College in 1846, and from the Cleveland Medical College in 1848. He spent two years traveling and studying in Europe and then addressed himself to the practice of medicine in Cleveland. In 1855 he joined the Army, and was sent with a Government expedition for exploring the region between San Francisco and the Columbian River. This region turned his attention to those sciences which became his life study, and the impulse toward them was further developed by the Ives expedition along the Colorado River in 1857–58. In 1859 he aided in exploring the San Juan and upper Columbia. During the war he was a member of the United States Sanitary Commission for the Mississippi Valley, and made inspections and distributed stores and means of shelter. In 1866 he became Professor of Geology in the Columbia School of Mines, and the development of the department of geology has been his chief work. He has collected the most extensive geological museum in the country, its specimens and exhibits numbering over 1,000,000 separate pieces. While actively engaged in the work of his professorship, he also, in 1869, reorganized and directed the Ohio Geological Survey. After this he took part in the New Jersey Geological Survey, was made Paleontologist to the United States Geological Survey, was a judge in the Centennial Exposition, was a corporate member of the National Academy of Science under appointment from Congress. He became President of the New York Academy of Sciences in 1867 and afterward of the Torrey Botanical Society. For a quarter of a century his opinion upon geological and mineralogical matters has been most highly esteemed and his services were frequently sought as a mining engineer. He had a stroke of paralysis in December, 1890, and was obliged to give up active work.

DR. WERNER SIEMENS, who died in Berlin, Germany, December 6, aged 76 years, was himself an eminent electrician, and was one of a prominent family. To his brother, the late Sir William Siemens, we owe the open-hearth steel process, and Sir William and Frederick, another brother, were the inventors of the regenerative gas furnace. The invention of the dynamo in its present form is a matter of dispute, but the honor of being the first to make a commercial machine belongs without doubt to Werner Siemens. He commenced life in the German Army. While holding his commission he invented the process of electro-gilding, of the differential governor and of the electric automatic recording telegraph. As member of a commission of the Prussian General Staff for the introduction of the electric telegraph system in place of optical telegraphs, he proposed in 1847 the application of subterranean conductors insulated by gutta percha, by means of a press invented by him for that purpose, which is still being used in the manufacture of cables. With the help of these insulated wires he succeeded in the spring of 1848, together with Professor Himly, in laying the first submarine mines with electric ignition for the protection of the harbor of Kiel from the Danish fleet. In the same year he carried out the first great telegraph line in Germany between Berlin and Frankfort-on-the-Main, and in the following year the subterranean line between Berlin and Cologne. Dr. Siemens left the government service in 1850, and devoted himself afterward entirely to scientific studies and to private enterprises. In 1847 he had already laid the foundation of the telegraph works afterward carried on by him under the firm of Siemens & Halske, in Berlin. Among his many achievements in science and the technical arts may be mentioned the invention and practical application of the quicksilver resistance unit, the gutta percha press, the development of methods for testing underground and submarine cables, and determining the position of faults in them; the invention of polarized relays, and the Siemens armature.

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers.—At the regular meeting, December 7, there was a long discussion on Mr. James D. Schuyler's paper on Asphaltum Lining for Reservoirs.

Mr. W. B. Parsons read a paper on Recent Test Borings on Broadway, which was discussed.

The following elections were announced:

Members: William H. Brown, Philadelphia; Howard Constable, New York; John N. Chester, New Rochelle, N. Y.; Loring G. Goddard, Dunham, O.; George S. Hayes, East Berlin, Conn.; Edmund G. Spilsbury, Trenton, N. J.

Associate Members: Edward T. McConnell, Indianapolis, Ind.; Henry F. Baldwin, Chicago.

American Society of Mechanical Engineers.—The meeting which began in New York, November 29, was a successful one, both in the large attendance and in the number of papers presented. Some of the latter were of much value, but the discussions were not as full or as general as at some previous meetings. Exceptions must be made, however, for two or three of the topical discussions, which called out some practical experiences worth noting.

The Society is in a prosperous condition, with a cash balance in the Treasury. It numbers now 1,569 members, and 94 new ones were added at the meeting.

American Institute of Mining Engineers.—The 64th meeting will be held in Montreal, beginning on February 21.

It is announced that the members of the Institute have subscribed $4,000, or its full share, to the fund for the expenses of the Engineering Congress in Chicago.

Roadmasters' Association of America.—At the annual meeting very full reports were presented on Rail joints, recommending the Fisher, the Long, and the McConway & Torley joints for further trial; on Methods of Fastening Rails to Ties; on Work Trains; on Block Signaling; on Treating Ties, and on Relaying Rails. All these reports were thoroughly discussed by the members, a large number being present.

The officers elected were: President, H. W. Reed; Vice-Presidents, W. H. Stearns and J. B. Moll; Secretary and Treasurer, J. H. K. Burgwin; Member Executive Committee, Robert Black.

It was decided to hold the next annual meeting in Chicago.

American Society of Naval Architects & Marine Engineers.—Some of the most prominent and influential men in the shipbuilding and shipping interests of the United States have completed the preliminary organization of a professional society of high standing to be called by this name, whose object will be to promote the art of shipbuilding in all its branches, both commercial and naval. The Committee of Organization—consisting of William H. Webb, of New York; Lewis Nixon, of Philadelphia; Colonel E. A. Stevens, of Hoboken; Francis T. Bowles, Naval Constructor, U. S. N., and Clement A. Griscom, President of the International Navigation Company—expect to incorporate the Society in New York, and are now sending out invitations to membership, hoping to have the first meeting at the time of the Naval Review.

The list of those who have accepted positions in the preliminary organization include many well-known names from all sections of the country: President, Clement A. Griscom; Vice-Presidents, T. D. Wilson, Chief Constructor of the Navy; Charles H. Cramp; George W. Melville, Engineer-in-Chief U. S. N.; George W. Quintard, New York; Irving M Scott, San Francisco; General Francis A. Walker, Boston; W. H. Webb, New York. The members of the council include H. T. Gause, Wilmington, Del.; F. W. Wheeler, West Bay City; Mich.; W. H. Jaques; General T. W. Hyde, Bath, Me.; J. W. Miller, New York; C. H. Orcutt, Newport News, Va.; Nat. G. Herreshoff; J. F. Pankhurst, Cleveland, O.; Naval Constructors Hichborn and Fernald, of the Navy; Charles H. Loring, ex-Engineer-in-Chief; Commanders Chadwick and Sampson, of the Navy; Harrington Putnam, of New York. Assistant Naval Constructor W. D. Capps is Secretary and Treasurer.

In consideration of the increasing importance of our shipbuilding interests and the development of the Navy, the organization of this Society upon a basis similar to that of the civil engineers and kindred professions is regarded as opportune and having a valuable and extended field of influence in technical subjects and public affairs.

Traveling Engineers' Association.—At a meeting held in Chicago, November 12, a call was agreed on and issued. It is signed by C. B. Conger, Chairman, and a number of others from different roads:

"We, the undersigned road foremen of engines, or traveling engineers, consider that an association of men in our calling would be beneficial in that an exchange of ideas would tend to uniformity in our work and to widening our information and usefulness, and, if properly conducted, would make the position of traveling engineer recognized as one of great usefulness to railroads and to enginemen. It would prevent friction by promptly rectifying small abuses; prevent waste by conducting a practical education and the encouragement of economical practices.

"We ask all traveling engineers and road foremen of engines to meet for the purpose of organizing an association similar to the Master Mechanics' Association, said meeting to be held at 2 P.M. Monday, January 9, 1893, at Room 912, No. 5 Beekman Street, New York City, office of *Locomotive Engineering*. If this meets with your approval, will you kindly correspond with John A. Hill, at above address, at your earliest convenience, stating if you will be present, or if not if you will join the association."

New York Railroad Club.—At the regular meeting, December 15, Mr. Alonzo Dolbeer read a paper on When Should a Locomotive be Destroyed? This was generally discussed.

Topical questions proposed for discussion were the difference in cost of Operating and Maintaining Locomotives in Freight Service at high and low speeds; and the use of Plain or Flangeless Tires. The attendance at the meeting was large.

Master Mechanics' Association.—Secretary Sinclair has sent out the following circular from the Committee on Boiler Attachments, consisting of James Macbeth, A. Dolbeer, W. A. Foster, James M. Boon and M. N. Forney. Replies should be sent to the Chairman, Mr. Macbeth, at Herkimer, N. Y.

BOILER ATTACHMENTS.

Among the subjects selected at the last annual convention of the American Railway Master Mechanics' Association for investigation by committees, and to be reported at the next meeting of the Association, is Boiler Attachments; how can the safety of these be increased, and how the number of holes in boiler for such attachments be lessened.

The undersigned have been appointed a committee to conduct this investigation and make a report thereon next year. With this end in view the Committee ask for information with reference thereto.

It is a well-known fact that in cases of collision or derailment a very common cause of accident to locomotive runners, firemen, and others, is that some of the boiler attachments are broken so as to leave an opening in the boiler from which steam or hot water escapes and scalds whoever may be fastened in the wreck. The aim of the Committee is to institute an inquiry to ascertain what can be done to prevent such accidents, or at least diminish their number, and with this end in view they ask for information concerning the following points:

First: Give a list of parts attached to your standard locomotive boiler which, if broken off in case of accident, would leave openings in the boiler.

Second: How could the number of openings in boilers for such attachments be diminished?

Third: In what way could such openings be protected to prevent escape of hot water or steam in case attachments are accidently broken?

Fourth: What is the best method of connecting check valves to boilers, flange joints or screwed direct into boiler. Give size of connection that should be used. Have you had any experience with inside check valves, and what is your opinion of their safety and efficiency compared with outside checks?

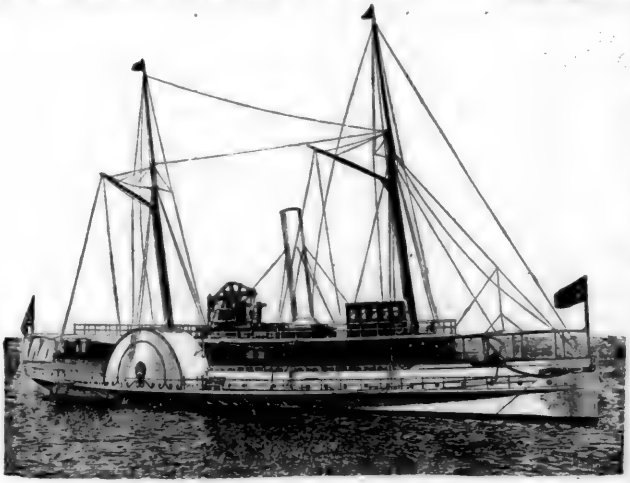
Fifth: Water Glass and Gauge Cocks.—Do you think it necessary or advisable to use water glasses in addition to gauge cocks? What size connection do you use? Is it advisable to use an automatic valve in water glass cocks to prevent the blow of steam and hot water in case of water glass breaking?

Sixth: Steam Chambers.—Is it your practice to use a steam chamber to connect the blower, injector valves, steam heating valves, etc., or is it your practice to connect these attachments separately to boiler? Is any provision made to close the connection between steam chamber and boiler?

The Committee would be glad if replies are not confined to the questions, but extended to any information bearing on the subject. Would also be pleased to have drawings and blue prints of any devices used on your line.

NOTES AND NEWS.

A Side-Wheel Yacht.—The illustration given herewith, for which we are indebted to the *Engineer*, of New York, shows the yacht *Clermont*, which differs from most of the steam yachts along the coast in having paddle wheels instead of a propeller. The *Clermont* has a wooden hull 160 ft. 3 in. long over all; 150 ft. 6 in. on load line; 25 ft. molded beam; 43 ft. over guards; 10 ft. 8 in. deep; 5 ft. 3 in. draft.



SIDE-WHEEL STEAM YACHT "CLERMONT."

The engine, which was built by the W. & A. Fletcher Company, New York, is of the beam type, with cylinder 40 in. in diameter and 6 ft. stroke; the wheels are of the feathering pattern, 17 ft. in diameter and 6 ft. 6 in. face. There is one steel return-flue boiler 8 ft. 1 in. in diameter and 26 ft. long; the usual working pressure is 60 lbs. There is also a donkey boiler carrying 125 lbs.; a steam windlass and other fittings. The boat is lighted by electricity, the dynamo being driven by an engine with 5 × 6 in. cylinder.

The actual speed of the *Clermont* in dead water is 18 miles an hour with 46 revolutions per minute. At this speed the engine develops about 800 H P. She was built for cruising and not for speed.

The *Clermont* is handsomely fitted up and has plenty of accommodations for passengers and crew. The advantages of the side-wheel type are speed on a light draft, quiet running with absence of vibration, and plenty of room.

A Geometric Boring Tool.—An ingenious device for boring holes of square, hexagon, star-shaped and other geometric sections is now being introduced by the Geometric Drill Company, of Philadelphia. It is in the form of an attachment which can be put on an ordinary drill press, and can be fitted to bore any shape of hole having straight or curved sides. While it would be difficult to describe this tool without illustrations, it may be said that it is quite simple. The movement of the boring tool is controlled by a cam, and it can be quickly adjusted to bore the shape desired.

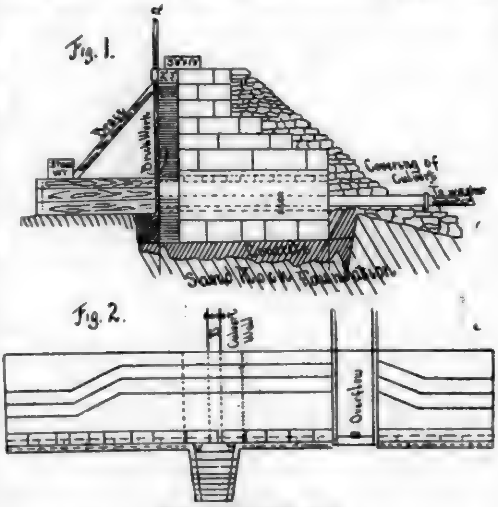
A recent inspection of this tool in operation showed some excellent work and a great variety of shapes. It can be used to bore simple round holes as well as other shapes.

An American-English Screw Factory.—The London *Engineering Record* says: "The new screw-making establishment, which has been built on the site of what were known as Whitham's Ironworks, at Leeds, and which is owned and conducted by the American Screw Company, of Providence, R. I., U. S., under the title of the British Screw Company, Limited, chartered under the laws of Great Britain, is being developed as rapidly as possible. The ground on which the works stand has an area of about five acres. The structure is 360 ft. in length, and has a frontage of 100 ft. The machinery is driven by a compound triple-expansion engine of 350 H.P., made by Messrs. Woodhouse & Mitchell, of Brighouse; the boilers, of 400 H.P. capacity, are from the works of Messrs. Babcock & Wilcox, Limited, Glasgow, and they have attached to them mechanical stokers. The factory is lighted by electricity, there being throughout it 500 incandescent lamps, and 45 arc lamps of 2,000 candle-power. The screw-making machinery has come from Providence. It has been running a couple of months, and at present about 12,000 gross of screws, of many different sizes, are being turned out per week. The heads of the different departments have also come from the home works in Rhode Island, but it is intended that they shall only remain here until English workers have been educated to fill their positions. It is, in fact, to be a thoroughly English manufactory so far as the workpeople are concerned. About 100, chiefly women and girls, have already found employment in the works, and it is expected that within a year from now some 500 or 600 will be at work."

A Simple Dam.—In many ore regions of the country the supply of water is by no means plentiful at any time, while at certain periods it fails almost altogether. As water is a prime necessity for washing the ore and for other purposes, an abundant and constant supply of water becomes a great desideratum, and in many places dams need to be constructed. A very simple dam, which can be easily constructed, is shown in the illustration on this page. It was built by the Rich Patch Iron Company, Low Moor, Va., and is the second dam of this company, which now has an abundant supply of water. A ground plan is shown, also vertical section.

The dam is 85 ft. wide, with an average depth of 11 ft. It is built of masonry embedded 4 ft. in the solid rock, and has a brick facing 18 in. thick on the water side. In both this dam and the one previously constructed by the company, the water is taken from the bottom, and this is considered quite an advantage. It passes through the dam by a 10-in. pipe, which is laid through the dam wall in a culvert. This is done to insure safety, and to avoid tearing out the masonry should any accident happen to the pipe. The pipe is bricked in between the walls of the culvert.

A protection has been provided extending 10 ft. from the face of the wall, which is designed to prevent any obstruction interfering with raising the gate. It consists of three 12 × 12-in. timbers bolted together, with two cross-ties at each end.



THE RICH PATCH DAM.

In the smaller and upper end have been inserted ten 2-in. iron bars 1 in. apart, to allow the water to go through. This protection is covered over and weighted down at its up-stream end, and also braced against the upright guides for the gate. The dam is also provided with two overflow gates 3 ft. wide and 3 ft. 6 in. high each, to be used in case of heavy floods.

The Rich Patch Iron Company informs us that the dams work excellently, and that it has been washing, with one Copeland & Bacon washer, 220 tons of ore per day from one dam. —*American Manufacturer.*

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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NEW YORK, FEBRUARY, 1893.

A CORRECTION.

Owing to the mistake of a photographer, the scale of the engraving of the New York Central locomotive No. 903, which was published last month, was not the same as that of the English engine illustrated with it. This was discovered last month too late to be corrected. We have, therefore, had the former re-engraved, and reprint both of them. Copies of the reprint will accompany the present (February) number. Both engravings are now made to a scale of ½ in. = 1 ft., and therefore show the relative size of the two engines. Those of our readers who preserve their papers should substitute the folded plate with this number of the Journal for the one attached to the January number.

EDITORIAL NOTES.

The next article in the series on Practical Railroad Information is necessarily postponed until next month; but the authors expect hereafter to continue this valuable serie without a break.

The convention of the National League for Good Roads, held recently in Washington, was largely attended. It was decided to apply to Congress for a charter, and to ask for an appropriation to enable the Department of Agriculture to make a general inquiry into the condition of the roads of the country.

The Executive Committee of the Master Mechanics' Association urges upon railroad officers the advantages to be gained by giving more attention to the standards of the Association and by following them in giving orders for rolling stock. Especial attention is called to the standard screw-threads and the sizes of wheel centers and tires.

As noted in another column, the Joint Committee of the Master Mechanics' and the Master Car-Builders' Associations has decided to hold the conventions next summer at Lakewood, N. Y., on Chautauqua Lake. There is said to be ample hotel accommodation there, and all the facilities required for the meetings.

The recent collision in the Japan Sea between the packet steamer *Ravenna* and the Japanese cruiser *Chishima-Kan* may throw some light on the possible results of ramming in a naval fight. The *Ravenna* struck the cruiser amidships, cutting her nearly in two, and had all the advantages of position which a ram could desire; but she suffered severely herself, the *Chishima-Kan's* protective deck cutting through her stem and bow plates for nearly 10 ft., and smashing in the bow so that the ship was kept afloat with great difficulty. It is evident that in a ramming contest the risk is not all on the side of the vessel attacked; the ram itself will run no small risk.

The readers of Mr. Chanute's earlier papers on Aerial Navigation will remember an account of the balloon *La France*, with which some interesting experiments were made in 1884–85. We are now informed by *La Nature* that a balloon on the same general lines as *La France*, but longer, is being built at the French military balloon works at Chalais-Meudon, under the direction of Commandant Renard. The new balloon, as described in *La Nature*, is 230 ft. long and 43 ft. in diameter at the center. The car is provided with a screw in front and a rudder behind and carries a gasoline motor. This motor is not fully described, but it is stated that it will exert an effective force of 45 H.P. on the shaft, and that its total weight, including a tank filled with gasoline, is about 66 lbs. per horse power. Making 200 revolutions per minute of the screw, it is calculated that the air ship will make headway against air currents not exceeding 40 ft. per second, or about 27 miles an hour.

The new balloon is to be ready for experimental use early in the spring.

The franchise offered for sale by the New York Rapid Transit Commission for building the underground line proposed by the Commission was not sold, only a single bidder appearing. His bid was not considered, as he only offered $1,000, and it did not appear that he was a responsible person. The result was generally anticipated.

The Commission is now considering applications for branches and extensions of the lines of the existing elevated road. One of the latter follows nearly the line laid down for an underground road.

ENGINEERS AND ARCHITECTS.

The *American Architect and Building News*, in commenting on a proposition of one of its contemporaries, that architecture and engineering ought to be united, or, rather, ought never to have been divorced from their ancient union, remarks:

To a certain extent this is reasonable, and architects ought to be and, we think, generally are, as familiar as engineers with the scientific principles of construction; but that they can with advantage treat their problems as an engineer does his is altogether too much to say. . . . In nine tenths of the engineering work of the present day the problem set before the designer is simply to get the strength required to resist dead-load, live-load, wind pressure and thrust, with the smallest possible expenditure of material and labor. In fact, nearly all structural engineering work is designed by or for contractors, who bid for the job in accordance with the designs they sub-

mit, and the one who has succeeded in "skinning" his project down to the lowest possible cost gets the contract. It is obvious that this sort of design is entirely unsuited to the temper and training which an architect should possess. (A good many of their clients have found this out.) It is one thing to study construction as the mediæval architects studied it, keeping beautiful effects always in their minds and using every new method of balancing pressures as a fresh artistic motive, and quite another thing to design a building with a sole view to straddling the space in the cheapest possible manner, without wasting a moment in considering the proportions of voids, spacing of horizontals, pitch of roofs, and the other considerations which take up so much of the architect's attention.

It must have been in this poetical spirit that the editor of the *American Architect* undertook to discuss the engineering subject of air ships, and tried to show how he could "straddle a space" without "wasting a moment in considering the proportions of voids." Here is the way he would do it: "It would be very easy, by using cylinders of compressed gas, to raise our air ship to the height required to launch it, and it ought not to be difficult to regulate the speed of the descent, by varying the position of the wings or by a horizontal rudder."

This principle evidently can have an extended application. In climbing mountains all a man need do is to carry a "cylinder of compressed gas" in each pocket to raise himself up hill; or, as tall buildings are now very much in vogue, cylinders of compressed gas might be substituted for elevators; and, as they say in patent specifications, other applications of the principle will suggest themselves, if "we only use every new method of balancing pressures as a fresh artistic motive to help us to straddle space."

In this case an architect "might with advantage have treated this problem as an engineer does his." If he had it would have appeared that coal gas, if compressed to about $\frac{1}{16}$ its volume, at atmospheric pressure, will be as heavy as air; and pure hydrogen, if compressed to $\frac{1}{14}$ its volume, would also be as heavy, so that it is hard to see how, in that condition, it would lift a balloon or anything else.

LOCOMOTIVE AND TENDER CONNECTIONS.

A COMMITTEE appointed at the last meeting of the Master Mechanics' Association, to make a report on "Attachments between Engines and Tenders," have recently issued their circular of inquiry. The questions they ask are a gratifying indication that the welfare and safety of the men who are engaged in the dangerous occupation of running locomotives is at least not entirely lost sight of by the members of the Association referred to, many of whom have, at some time or other, been locomotive runners or firemen themselves. It is not necessary to quote statistics to show that running locomotives is a dangerous occupation. That it is so is well known, but the relative amount of danger arising from different features of construction of locomotives has never been clearly shown. Probably more men are killed and injured by being caught and crushed between their engines and tenders in cases of collision and derailment than in any other way. This class of accidents until quite recently seems to have been regarded as unpreventable and incapable of diminution. The circular of the Committee referred to indicates that at least some of those who prepared the circular are disposed to think that something could be done to mitigate this source of risk to which men on locomotives are exposed. The first question of the circular is as follows:

1. With engines coupled to tenders by a single stout link and large pins so strong as not to break loose under the heaviest pull, have the tank-frames any marked tendency to either mount or run under the cab foot-plates? In other words, is there any more risk from the tender-frame than there is from the tank leaving the frame and sliding into the cab?

In view of the fact that there are a great many members of the Master Mechanics' Association who are able to say definitely from their own observation or experience whither, in cases of accidents, tender frames *do* "mount or run under the cab foot-plates," it would seem to be idle to argue about a "tendency." If the Committee had asked the question whether members have known of tender frames mounting or running under the foot-plate in cases of collision or derailment, and they would answer the question, it is believed that an abundance of testimony would have been elicited to show that that occurs very often. An ordinary draw-bar between a locomotive and tender is usually about 4 ft. long from center to center of pins, and is often bent so that the middle portion stands at a greater or lesser angle to a horizontal line. Owing to the inclined position of the bar the "tendency," in case of a severe collision, is to push its front end upward and carry the foot-plate and back end of the engine with it, and to depress the back end of the bar and the tender, thus facilitating the running under of the latter. The concussion thus exerts a downward force on the back end of the draw-bar, and an upward force on its front end. These forces, being exerted on the ends of the bar, act with a leverage equal to its length on the castings to which it is coupled, tending to pry open the pockets which receive the ends of the bar. Considering the force of a collision, the length and size of the bar, the leverage with which the force is exerted, and the comparative weakness of the castings and bar, it is evident that, under these conditions, they would offer little effective resistance to prevent the engine and tender from "mounting."

In case of collision the position which the engine and tender will assume is of course very uncertain. The front end of the engine may be raised up and the back end depressed so as to facilitate the mounting of the tender on the foot-board. All that we want to point out here is that the draw-bar does not give adequate protection to prevent such accidents.

The second and third questions of the circular are:

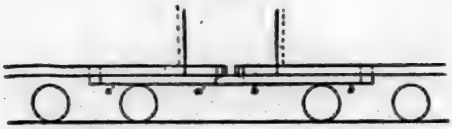
2. If tender-frames have such a tendency, can it be prevented? If so, is the probable expense, weight and work required to prevent it in your opinion justified?

3. If you are not using such a device, are you familiar with any fastening, equipment or invention that is designed to prevent tender-frames from mounting? If so, will you illustrate or describe it?

It is claimed for the vestibule system that it effectually prevents cars from telescoping. When this occurs, the floor timbers of one car always mount on top of the platform of the other. This to a certain extent would be prevented by the construction of the vestibule. A proposition to put vestibules between engines and tenders, even though they did save life, would probably not meet with much favor with railroad managers. Another arrangement which has been devised for preventing the telescoping of cars, and which has been in use for many years on the Chicago & Alton Railroad, is the Blackstone platform, a diagrammatic side view and plan of which is shown in figs. 1 and 2, and which has heretofore been illustrated and commended in these pages. The principle of this, it would seem, could be readily applied to the connection of engines and tenders. The peculiar feature of the platform is shown in the two views. At each end of the cars two safety-beams, *a a*,

a' a' and *b b, b' b'*, which project beyond the buffer-beams, are fastened below the floor-sills. The safety-beams are not placed at equal distances from the center of the car, but one is further from it than the other, so that when one car adjoins the other, as shown in the plan, fig. 2, the safety-beams interlock with each other as shown. It will also be seen that

Fig. 1.



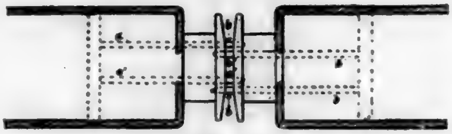


Fig. 2.

those on the one car project under the buffer-beam of the other, so that the one car cannot raise up or be depressed without taking the other with it. In this way the floors are kept in line, and the longitudinal beams which form the car frames must resist the shock of collision.

If applied to locomotives and tenders, the beams, instead of being made of wood, might be of iron, and might be made in the form of hooks similar to a letter **L**, the vertical part being fastened to the end of the engine or tender frame, and the horizontal portion would then project under the adjoining frame to the one to which the beam is attached. In fact, projections might be forged on or bolted to the back ends of the engine frame which would project below the tender frame. The expense of such an arrangement would be very slight, and would save many a poor fellow from death or injury and unspeakable suffering. Who will be the first to give it a trial?

Before this is done, a few words of objurgation may do some good. There is a curious tendency in human nature to be penurious. This tendency is not confined to money, or what can be represented by dollars and cents. Many people are penurious in quantities, which are not convertible into dollars and cents—they will be stingy in feet and inches, in pounds and gallons, when these have no value. The unwillingness of an ordinary mechanic to give ample bearing surface to journals and other mechanical structures is an illustration of what we mean. The inadequate supply of air in the ventilation of cars and houses is another. It took many years of exposure and many disastrous accidents before engineers overcame this kind of penuriousness and built bridges and steam boilers of ample strength to resist the strains to which they are subjected. The advice often quoted in these pages, "If you must make a thing strong, make it profanely strong," expresses resentment to this kind of meanness.

Now, if any one should undertake to apply the principle of Mr. Blackstone's platform to engines and tenders, for the protection of the men who run them, it is hoped that he will remember that the safety of human lives and limbs will be dependent on the strength of these appliances, and therefore a very large factor of safety should be allowed.

The Committee have also taken up the subject of footsteps and hand-rails for locomotives and tenders, and ask the following questions:

Are long steps safer or more advantageous than short steps having good, high flanges to prevent the side movement of the foot after it has once touched the step?

Are there any materials for steps (or the working faces of steps) safer and better, in all states of weather and greasiness, than roughened iron?

If so, what are the qualities they possess? Illustrate or describe the manufacture, shape and size, saying how the material is used.

Should side steps on engine and tender be the same height—that is, in line the one with the other?

What is the best height from top of track tie to working face of step? Would increasing the number of steps and lessening the vertical height (or the riser) in your estimation add to the safety of the men?

Are the long, upright handles safer and more effective than short handles?

Is there any usefulness in long, horizontal hand-rails on tank?

Are low hand-rails and foot-steps desirable at the front end of any engine equipped with a pilot?

If any improvement in hand-rails or foot-steps is desirable on yard engines, should not road engines be similarly equipped, both for safety and uniformity?

The replies of master mechanics, and, if it were possible to get them, answers from experienced locomotive engineers, to these inquiries would be very interesting. Considering the danger to which these men are exposed, the subjects on which the Committee are to report have never received the attention which they should. We have no data at hand to show the number of engineers and firemen who are killed or injured annually in this country, but it must be very large. The attending suffering is inconceivable, and the distress which is a consequence of such accidents is incalculable. From motives of humanity, then, the Committee should give the subject all the attention possible, and the Association will incur a grave responsibility if they fail to take action on any measures presented for their consideration which would give greater safety to the men who are now exposed to so much danger.

It is a matter, too, which would be a very proper one for the Brotherhood of Locomotive Engineers to take up. There are now no statistics which show clearly the exact causes of accidents to locomotive engineers and firemen. If the Brotherhood should take action, requiring each division to appoint a committee, whenever an engineer or fireman was disabled from an accident, to report the extent of his injuries, with a brief statement of how the accident occurred and the causes of it, and if these reports were published monthly or quarterly, so that they could be tabulated and analyzed, they would be sure to indicate the most prolific causes of such accidents and point out how, or at least the direction in which measures should be taken to prevent them.

RECENT INVENTIONS IN ARMOR.

The files of the Patent Office, even at this late day of armor development, show many curious devices in the way of armor construction, and remind one of the early days when wire rope, rubber in all sorts of combination with iron, compressed wool, hogs' hair, etc., were brought forward by sanguine inventors to match artillery projectiles.

Two recent patents for armor plate possess at least the quality of novelty—the one covering a method of constructing and applying the plate to a ship's side; the other a device for face-hardening or carbonizing it during the process of casting.

The "Henry Clay improved armor plate" is double—a thick plate attached to a ship's side in the ordinary way, while in front of it is suspended a thinner face plate. This latter

is provided with projections or pistons which fit into corresponding recesses in the under plate, with the expectation, as the inventor says, that the air chambers thus formed will, "upon a blow of a projectile striking the outer or exposed plate, serve as cushions, whereby the force or impact of the blow is, as stated, absorbed, and the penetration of the plate by the projectile prevented." A series of elliptical springs between the plates hold them apart, so that the pistons barely enter the corresponding recesses.

Without considering any of the mechanical difficulties in the way of successfully constructing and applying armor plate as thus proposed, or its necessarily great cost, it may be said in advance of experiment that there is no likelihood of its behaving in any such way as expected by the inventor. Matched against a spherical projectile moving with a low velocity, it is quite possible that something might be gained in resisting power by a plate so constructed. As against a projectile from a modern rifle, with a velocity of 2,000 ft. or more per second, it is safe to predict that before the outer plate could bring up its reserves of elasticity stored in the chambers under the pistons, the projectile would be through this outer barrier uninjured and ready to do its work upon the softer plate beneath. Particular reference to this plate has been made for the reason that it is constructed upon a theory that every armor-plate experiment since the advent of the high-power rifle has proved to be erroneous—a theory to which all the advocates of compound armor are wedded. The fact above all others that recent armor trials have demonstrated is that no quality in the substructure of an armor plate, be it elasticity, ductility, or strength to resist rupture, can compensate for the lack of sufficient face hardness to break up or throw off the shot. In other words, the outer barrier must of itself be equal to stopping the projectile if it is to be stopped at all; there is no time, so to speak, to call up reinforcements or fall back upon reserves.

Under the title of an "Improvement in the Process of Casting Armor," Messrs. Chase & Gantt propose to secure face hardness by constructing the mold walls wholly or in part of manganese, silicon or other fusible material with which the steel will alloy. The walls of the mold will, it is claimed, when brought in contact with the molten metal, combine and alloy with the steel, hardening the surface thereof, the hardness diminishing toward the interior.

If by the use of such molds a sufficient and uniform degree of hardness can be obtained, it can hardly be doubted that a step in advance has been made in the methods of casting steel for armor plates, especially as plates thus cast may be further improved by forging or rolling, oil-tempering, and similar processes.

THE OCHTA ARMOR TRIAL.

The recent armor trials at Ochta, Russia, have scored another victory for the American or Harvey method of treating armor-plate. This trial is particularly noteworthy as testing the relative merits of the Harvey and Tresidder processes of armor making upon the same trial ground. Much was expected from the latter plate, and it was considered by many as the most formidable rival of the American plate in the field. In both systems the aim is to give the plate sufficient face-hardness to break up projectiles and prevent penetration.

The Harvey plate, as is well known, is of mild nickel steel, face-hardened by carbonization. In the Tresidder process this face hardness is given by subjecting the heated plate, which may be all steel or compound, to the action of a cold-water douche. The Harvey plate used in this trial was made in England by the Messrs. Vickers; the Tresidder plate, which was a Brown (Ellis) compound, by John Brown & Company, of Sheffield.

In this trial five plates were tested—two Cammell all steel, one of hard and the other of soft steel; a nickel-steel Schneider (French); and an American Harveyized nickel-steel plate. The trial of the first four plates mentioned took place on November 23; that of the last was, for some unknown reason, postponed until December 13.

The conditions of the trial were: Plate, 10 in. in thickness; projectiles, six 6-in. Holtzer steel, weighing 90 English lbs., with an average striking velocity of 2,178 ft. per second. Briefly summarized, on the first day's trial the Cammell hard steel plate went to pieces at the end of the third round; the Cammell soft steel withstood the six shots without cracking until the last shot, but the penetrations were from 12 to 21¼ in.; the Schneider plate threw off all the projectiles either intact or partially broken up, with an average penetration of about 12 in. and no cracks; the Brown-Tresidder plate began breaking up at the first round, and was ruined at the end of the fifth, breaking up all of the projectiles. At the end of this day's trial the French plate was far ahead of any of its rivals.

On the second day's trial the Harvey plate, after throwing off four projectiles without cracking, and with only slight penetrations, was attacked with two 9-in. 400-lbs. shot, the first of which started a number of cracks and the last broke off a lower corner of the plate, but leaving the backing uninjured.

The victory for the Harvey plate was complete and unquestioned. The result showed great face hardness without brittleness, a combination of qualities difficult to obtain, and which approaches more nearly the ideal armor-plate than anything ever before brought to the trial ground.

THE PARISIAN INVENTORS' ACADEMY.

That there are a considerable number of scalawags in Paris is shown by the recent revelations of transactions in connection with Panama Canal affairs. That there are still more of the same genus besides those who helped to swindle the stockholders of that great scheme is shown by the following proposition just received by the editor of this paper:

Paris, 15 *Faubourg Montmartre*,
the 6 of Janvier, 1898.

Matthias Forney, Esq.:

Sir: We beg to inform you that after the examination of your last invention the Parisian Inventors' Academy has conferred upon you the title of Member of honour (*membre d'honneur*) *with award of the first class Diploma & the Great gold medal*. (*Plated*)

This honorable title will be of no expense to you, but if you are desirous to receive the Medal and Diploma, you would have to send us a Post money order of ten dollars (or currency per registered letter) to cover admission taxes freight, etc., and we shall send both well packed and free of charge to your address.

Trusting that our invitation will be favorably received, we are at your disposition in *Invention and Patent maters* according to the Academy which are enclosed, and

We remain, Sir, Your obedient servant

E. Boettcher,
President.

The editor of this paper has not hastened to send a "Post money order of ten dollars" in response to the above, although he must confess that he felt flattered at having received so distinguished a title for so modest an invention as an improvement on car seats. He is somewhat like the man who received a present of Limburger cheese, and who acknowledged its receipt by writing that he "never knew anything to taste so good that smelt so bad." The editorial "We" of this paper

makes the request publicly that *after* he receives the "Great gold medal (Plated)" that all correspondents address him with his full title of "*membre d'honneur*," and he will then seek for admission into a lunatic asylum.

NEW PUBLICATIONS.

PROCEEDINGS OF THE TWENTY-THIRD ANNUAL CONVENTION OF THE MASTER CAR & LOCOMOTIVE PAINTERS' ASSOCIATION OF THE UNITED STATES AND CANADA: HELD AT DETROIT, SEPTEMBER 14, 15 AND 16, 1892. *Corrected and Approved by the Secretary.* Philadelphia; published for the Association by the *House Painting and Decorating* Publishing Company.

The Association, whose annual convention is reported in this handsomely bound and printed volume, has done much good work during the term of its existence, and the present report shows that its activity does not diminish with age. The report contains some excellent papers and records of experience and of tests and experiments made; and many of the discussions are pointed and sharp, giving accounts of individual experience which may serve as valuable guides to other workers in the same line.

POOR'S HAND-BOOK OF INVESTMENT SECURITIES. THIRD ANNUAL NUMBER, 1892-93. New York; H. V. & H. W. Poor, No. 70 Wall Street.

This volume makes its appearance this year in greatly enlarged form, having 986 pages, or about twice the number of last year. This implies an increase of the ground covered, as well as greater completeness in the work, and the publishers evidently intend that the book shall completely occupy the field. Besides railroad securities it has lists of State, county and municipal issues; banks and a large number of industrial corporations are also included in the lists.

Besides lists of securities and information as to stocks and debts of the various corporations, the *Hand-book* gives statements of the dividends paid; location of transfer offices and agencies; time and place of annual meetings, and other particulars which it may be serviceable for an investor to know. Tables showing the range of prices at the New York Exchange and at those of other leading cities are also given, and in fact almost all the information which can be collected and given in a condensed form, and which bears on the present or prospective value of a security.

CURRENT READING.

AMONG the books announced as in preparation by Messrs. John Wiley & Sons is a PRACTICAL TREATISE ON FOUNDATIONS, by W. W. Patton, which will soon be ready.

The December number of GOLDTHWAITE'S GEOGRAPHICAL MAGAZINE is an excellent one, with much good reading in it. There are articles on Mars; the Panamint Indians of the Mojave Desert; the Republic of Honduras; Longitude and Time; Antarctic Exploration; Influence of Rainfall on Commercial Development; and several other topics, besides the usual editorial departments. None of the articles are long, and all are readable.

The JOURNAL OF POLITICAL ECONOMY is a new quarterly, issued from the University of Chicago. The first number has papers on the Study of Political Economy in the United States, by J. Laurence Laughlin; the Recent Commercial Policy of France, by Emile Levasseur; Rodbertus' Socialism, by E. B. Andrews; the Price of Wheat since 1867, by T. B. Veblen; Notes, by Edward Atkinson and others; and book reviews. This table of contents will give an idea of the general scope and objects of the new review, which is addressed to thinking men and deserves to succeed—as we certainly hope it will.

The JOURNAL of the Military Service Institution for January has a continuation of General Tidball's interesting papers on Artillery Service in the Rebellion. Other articles are on Hot Air Balloons, by Captain Zalinski; Military Specialists, by Captain Hess; the Knapsack, by Captain Quinton; Musketry Training, by Captain Parker; Place of the Medical Department in the Army, by Lieutenant Williams; and several excellent translations and reprints.

The January number of the ECLECTIC MAGAZINE opens with an article on the Ruin of the American Farmer, from the *Nineteenth Century*. Other articles are from the *Fortnightly Review*, *Macmillan's Magazine*, the *Spectator*, *Blackwood's Magazine*, the *Contemporary Review*, the *National Review*, *Temple Bar* and the *Cornhill Magazine*, presenting an interesting selection of current English literature.

The February number of OUTING is fully up to the usual standard, and continues with undiminished zeal to preach the gospel of healthy exercise and open-air sport.

In the OVERLAND MONTHLY for February there are illustrated articles on the Digger Indians of 30 Years Ago; Santa Barbara in January; Life in the Napa Insane Asylum; and Football in California. Several shorter articles help to make up a very interesting number.

The February number of GODEY'S MAGAZINE, besides a complete novel by Edgar Fawcett, has several good articles, including one on the growth of the Chautauqua Idea, by George E. Vincent, and one on Mont St. Michel in Brittany. The several departments and the fashion plates will be welcome to engineers' wives and daughters, if hardly of deep interest to the engineers themselves.

The January number of the ENGINEERING MAGAZINE has articles on the Outlook for Foreign Markets; Industrial Development of the South; Geology and the Mississippi Problem; the Anthracite Coal Industry; Fire Losses and the Age of Clay; the True Cause of Labor Troubles; the Pan-American Railroad Surveys; Liquid Fuel in Steam Making; and the usual special editorial departments, which are full of interesting notes in this number.

The February number of SCRIBNER'S MAGAZINE has articles on travel in the Tyrol; on Tangier; on Florentine Artists; and a variety of interesting sketches, with some excellent fiction for those who enjoy light reading.

The series of articles on the Development of American Industries since Columbus will be resumed in the POPULAR SCIENCE MONTHLY for February, with an opening paper on the Glass Industry, by Professor C. Hanford Henderson, in which the history of glass-making during colonial times is traced. Among the other articles are included one on the Marine Biological Observatory at Wood's Holl, by Professor C. O. Whitman, and one on Ghost Worship and Tree Worship, by Grant Allen.

The February number of HARPER'S MAGAZINE contains a number of handsomely illustrated articles, including several of special interest.

The ARENA for February continues the work of discussing important topics as fully and carefully as usual. All thoughtful readers should see the list of subjects and writers already secured for this magazine during the current year.

The recent numbers of HARPER'S WEEKLY continue the work of illustrating the Columbian Exposition building. Among other notable articles recently have been those on the Capital Cities of the World; Brussels is the latest, and both text and engravings are excellent.

The February number of the NORTH AMERICAN REVIEW

has a list of articles well worth reading. This magazine is one that can hardly be passed over by those readers who want to be posted on the questions of the day.

The fifth number of the JOURNAL OF THE UNITED STATES ARTILLERY is chiefly given up to the discussion of rapid-fire guns, the claims of the Krupp, the Canet and the Schneider types being presented by different authors, while the questions raised are summed up in a concluding article.

BOOKS RECEIVED.

Sixth Annual Report of the Interstate Commerce Commission: December 1, 1892. Washington; Government Printing Office. Some references to this report will be found in another column.

Transactions of the Technical Society of the Pacific Coast: Volume IX, Number 11. San Francisco; published by the Society.

Report of the Chief of the Bureau of Medicine and Surgery to the Secretary of the Navy: 1892. Surgeon-General John Mills Browne, U.S.N., Chief of Bureau. Washington; Government Printing Office.

Annual Report of the Chief of the Bureau of Statistics, Treasury Department, upon the Foreign Commerce of the United States for the Year ending June 30, 1892. S. G. Brock, Chief of Bureau. Washington; Government Printing Office.

Massachusetts Institute of Technology: Department of Civil Engineering. Prospectus and Programme for 1893. Boston, Mass.; published by the Institute.

Duty Trial of a Fly-wheel, High-duty, Automatic Cut-off, Cross-compound, Pumping Engine, designed and built by the George F. Blake Manufacturing Company. New York; published by the Company.

Report to the Railroad Commission of California upon Just and Equitable Rates of Freights and Fares for the Railroads of California. By Richard Price Morgan.

Atmospheric Resistance and its Relations to the Speed of Railroad Trains; with an Improved System of Heating and Ventilating Cars. By Frederick U. Adams. Chicago; published by the Author.

TRADE CATALOGUES.

THE present year does not seem to be a good one for *Calendars,* of which a smaller number have been received than usual. A very neat one for the pocket, including a calendar for the year and a memorandum page for each day in the week, is issued by the *New York Equipment Company.* One of the neatest of the monthly calendars is that sent out by Mr. *Robert A. Keasbey,* bearing a very modest advertisement of his well-known magnesia sectional covering on its outer case.

Illustrated Catalogue and Price-list of the Athol Machine Company and the Standard Tool Company. The Athol Machine Company, Selling Agents, Athol, Mass.

This catalogue shows a great variety of vises, squares, gauges, calipers, levels, wrenches and other tools which the machinist finds necessary in his work. It is well illustrated and the prices are given in every case—a great convenience in a catalogue of this kind. Every mechanic who wants to do good work and to have the best tools to do it with ought to have a copy of this catalogue.

To the Roadmasters of America: A Souvenir. The Bush Cattle Guard Company, Kalamazoo, Mich.

This very pretty pamphlet contains a number of illustrations of the recent trip through the South made by the members of the Roadmasters' Association of America. It is well printed and bound, and the roadmasters who receive it will doubtless appreciate it fully—as well as the thoughtfulness of the Bush Cattle Guard Company in providing it.

Improved Hydraulic Jacks; Screw and Lever Jacks. The W. & S. Hydraulic Machinery Works, Watson & Stillman, Proprietors, Nos. 204–210 East 43d Street, New York. Illustrated.

This price-list gives descriptions and illustrations of a number of hydraulic jacks designed for general use and for special purposes; also of several patterns of screw-jacks, of a screw hoist and a tube expander made at the well-known works from which it is issued. Some directions for the proper use and care of hydraulic jacks and for their repair are also given, making it a useful and convenient pamphlet.

Consolidated Car-Heating Company. Part II, Sewall Steam Coupler, and Part III, Improved (McElroy) Commingler. Albany, N. Y.

Part II of the Consolidated Car-Heating Company's catalogue begins with a description and illustration of the Sewall steam coupler for connecting the flexible hose which is used between cars in heating them by this company's system with steam taken from the locomotive. A list of railroads using this coupler is then given, which is followed by a statement of the advantages claimed for it.

Instead of giving a series of letters of recommendation of this system in full, as is generally the custom, and which are usually too long to be read by busy men, this company have given only short extracts from such letters which take little time to be read, and occupy only a small portion of space. It is thought, though, that these recommendations would have been more satisfactory if the names of the writers had been given.

After these extracts, directions for the use of the Sewall coupler and the measurements required for applying it. The pamphlet concludes with a list of parts of the coupler, some remarks about car heating hose and the guarantee thereof, and of the number of patents owned by the company.

Part III of their catalogue is on the improved (McElroy) commingler system of heating. This system is explained in the first paragraph of the pamphlet, in which it is said:

In continuous train heating from the locomotive, the most satisfactory forms of apparatus have been those in which steam from the locomotive is employed to heat a water circulation within each car of the train. The even and agreeable temperature found when water is employed as a heating medium is due to the great capacity of water for absorbing and storing heat when too much heat is admitted to the car, and for yielding up the stored heat when there is not sufficient steam to maintain an even temperature.

The "commingler" itself consists of a pear shaped vessel, on the inside of which is a perforated steam pipe connected with the supply pipe from the locomotive. The perforated pipe is surrounded with pebbles, through which the escaping steam must pass, and which makes the discharge noiseless. To the upper part of the commingler the hot-water pipes are connected. The flow of steam is broken into hundreds of small jets within the body of pebbles in such a manner as to silently force the water through the commingler and into the hot-water pipes after imparting to the water the entire heat of the steam.

The first five pages are devoted to an explanation of the system, which is illustrated by a number of excellent engravings. The mistake has been made—which is very common in trade catalogues—of assuming that the readers know a great deal more of the subject discussed than they generally do. The description of the system is not sufficiently explicit and detailed. It would add to the interest and value of the publication if there was a clear description of the general principles of the system;

then a detailed account and explanation of how it works, showing clearly the direction and course of the circulation of the steam and water, and then full, detailed illustrations and descriptions of the different parts. Men who write books of this kind, and who know all or nearly all that needs to be known about the subject of which they are writing, should try to assume the attitude of mind in regard to the apparatus described that a person who knows nothing at all about it must occupy. It should also be kept in mind that a considerable proportion of the people who will, or should, read a pamphlet of this kind will be more or less stupid—usually more—and will not be quick in apprehending a description of any mechanism. Whatever is written, therefore, should be made as clear and as explicit as possible. The same remarks will apply to the illustrations. *Lucidity* is the characteristic to be aimed at in all such and other publications.

The descriptions in the pamphlet before us are, however, full enough to enable any one familiar with the general subject of steam heating of cars to understand the system explained; but the usefulness of it would be widened if the needs of those who are totally ignorant of what is explained and also those of the wayfarer and fool were kept in mind.

Following the description of the commingler system is a statement of its points of advantage and directions for operating it. Then follows a detailed description, illustrations, and a list of the different parts.

The second portion of the book has a description and a very good engraving illustrating the commingler storage system. This is treated in a similar way to the return system.

In the third part the commingler return system for elevated and English railroad cars is described.

Both of the pamphlets are well illustrated and printed, and will be of interest and use to all who are concerned in the important subject of which they treat. Our criticisms apply not especially to them, but to trade catalogues generally.

A Story of To-day: Sioux City, its Commerce and Manufactures. Sioux City, Ia.; Compiled and Published by the Jobbers' & Manufacturers' Association. December, 1892.

AMERICAN AND ENGLISH LOCOMOTIVES.

With this number of the Journal we give very complete illustrations of the boilers of the two engines illustrated by general views last month. The striking feature of the difference in the size of the two boilers appears if we compare figs. 8 and 13, although this difference has been slightly exaggerated by the fact that in photographing the blue print from which fig. 8 was taken allowance was not made for the shrinkage of the print, whereas fig. 13 was made direct from a drawing. The extended smoke-box of the American boiler also adds to this exaggeration. The real difference is shown by the amount of grate and heating surface in the two boilers which, as given last week, is as follows:

	Grate Surface.	Heating Surface.
American engine	27.3 sq. ft.	1821.5 sq. ft.
English "	18. "	1367.76 "

The American boiler, therefore, has 51.6 per cent. more grate and 33.1 more heating surface than its English cotemporary. If we take the sum of the cubical contents (in inches) of the spaces swept through by the pistons during one revolution of the wheels and divide by the circumference of the wheels in inches, we will find that the cylinder capacity of the English engine is 110.4 cub. in. for every inch in the circumference of its wheels, whereas the American engine has only 102.5 cub. in. It will thus be seen that the American engine has more boiler and less cylinder capacity than Mr. Adams's engine. The effects of these differences in proportion will be discussed when we come to consider the performance of the two engines. The following are the

SPECIFICATIONS FOR BOILER OF AMERICAN LOCOMOTIVE.

Boiler.—To be of the best workmanship and material; to be capable of carrying with safety a working pressure of 180 lbs. per square inch, and of sufficient capacity to supply steam economically. All horizontal seams with butt joints quadruple riveted, with welt strips inside and outside. A double-riveted seam uniting waist with fire-box. All plates planed at edges and caulked with round-pointed tool. Boiler to have extended front end. Waist, dome and outside of fire box of steel ½ and $\frac{9}{16}$ in. thick; throat, ⅝ in. thick. Diameter of waist at front end, 58 in., made wagon top, with one dome 30 in. in diameter placed on wagon top.

Fire-box.—Of best quality of fire-box steel, 96$\frac{3}{16}$ in. long, 40⅛ in. wide; Front, 70¼ in.; Back, 58¼ in. deep. Crown-sheet, ⅜, tube-sheet ½, side and back sheets $\frac{5}{16}$ in. thick. Water space, 4 in. front, 3 in. sides, 3 in. back. All sheets thoroughly annealed after flanging. Fire box ring double riveted. Staybolts ⅞ and 1 in. in diameter, screwed and riveted to sheets, and placed not over 4 in. from center to center.

Crown-sheet supported by crown-bars made of two pieces of wrought iron 5 in wide, ⅝ in. thick, placed not over 4½ in. apart, reaching across crown and resting on edge of side-sheets. Crown-bars riveted to crown-sheets with ⅞-in. rivets placed not over 4 in. from center to center, each bar having four stay-braces to top of boiler or dome.

Tubes.—Of charcoal iron 11 W. G., 268 in number, 2 in. in diameter, 12 ft. in length. Set with copper ferrules at both ends, swedged at back end and beaded both ends. Cleaning-holes at corners of fire-box, and blow-off cock in throat.

Grate.—Rocking.

SPECIFICATIONS FOR BOILER OF ENGLISH LOCOMOTIVE.

Boiler Plates.—The barrel, smoke-box tube-plate, fire box casing and throat and back plates of fire-box, also all dome-plates and butt-strips to be made of the best mild steel of the exact dimensions, both as regards form and thickness, as given on the drawings. To be supplied by makers approved by the Railway Company's Locomotive Superintendent.

Quality.—The quality of the material to be that generally known as mild steel plate, and to be free from silicon, sulphur or phosphorus. The ultimate tensile strain that the plates will stand to be not less than 25 nor more than 30 tons per square inch, and to have an extension of not less than 23 per cent. in 10 in.

Manufacture.—All plates to be made in the most approved manner from ingots hammered on all sides, and, when re-heated, to be rolled truly to a uniform thickness. Both sides to be perfectly clean and free from pitting, roll-marks, scale, dirt, overlapping, or other defects. Each plate to be taken from the rolls at a full red heat, and allowed to cool gradually on a flat surface. Each plate is to be sheared to the dimensions given, and in no case to be sent out before being leveled sufficiently true for machining. All plates that are wavy or buckled, or in any way defective, will be rejected, and must be replaced by the makers free of cost. The maker's name and date of manufacture must be legibly stamped on every plate, and not nearer the edges than 9 in.

A sample or test plate at least 2 ft. square must be sent in by the maker as a sample of what will be supplied in the plates to be made under this contract, together with a complete analysis of the same. This test plate is to be ½ in. in thickness, and from it pieces will be taken for proving in the following manner:

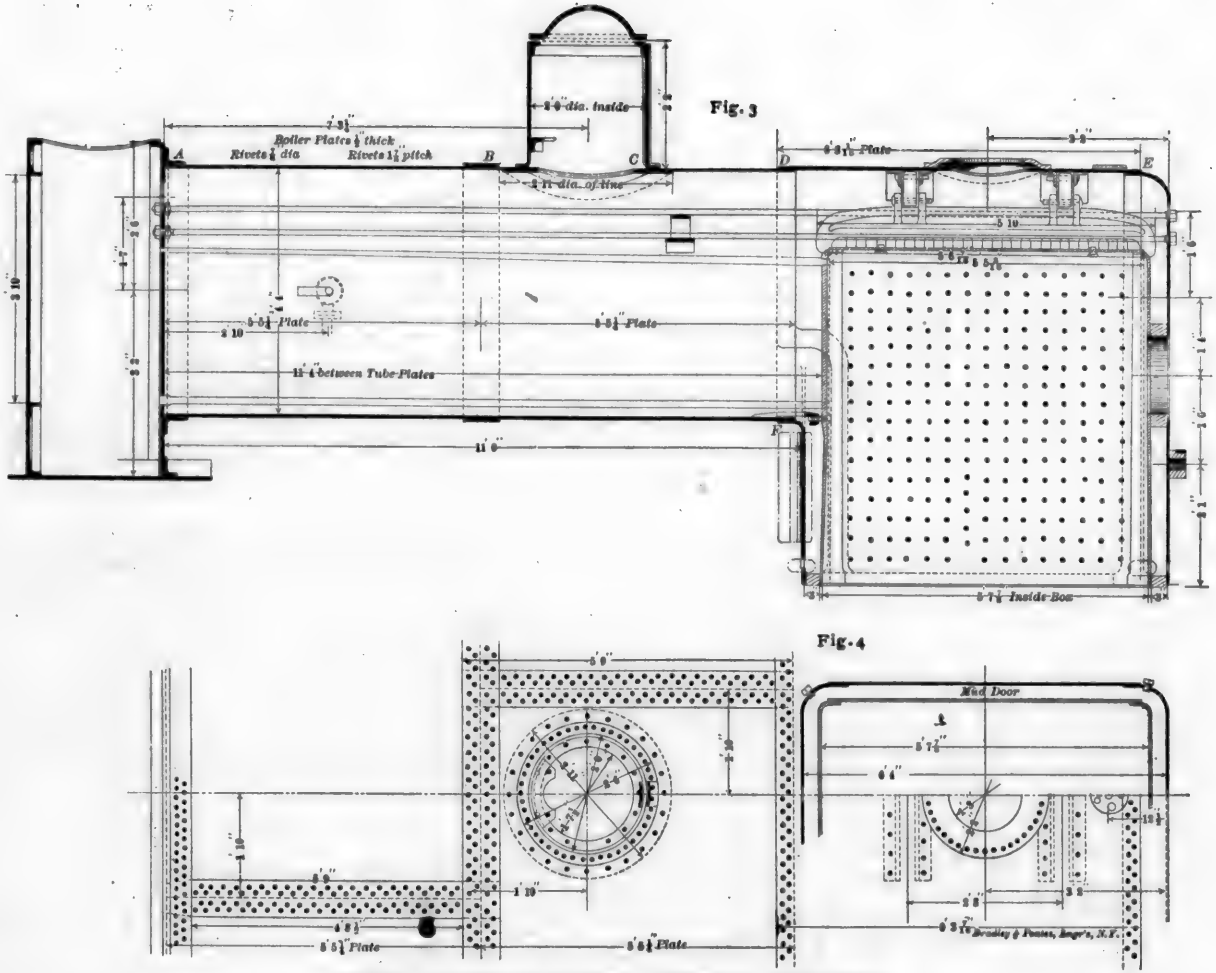
Test.—A piece 6 in. long will be bent over cold until the ends meet each other closely, and no fracture or sign of failure is to be observable in the heel of the bend. Pieces 3 in. wide will also be taken and a ⅞-in. hole punched through same, which shall stand being drifted cold by taper drifts until it reaches 1¼ in. in diameter without the edges fraying or showing signs of fracture.

Samples or shearings from the plates must be tested in the presence of the Railway Company's Locomotive Superintendent or his Inspector, on the premises of the maker, whenever desired.

The barrel and fire-box casing plates to be thoroughly annealed after the rivet holes are punched.

The smoke-box tube-plate, throat and back plates of the fire-box to be thoroughly annealed after they have been both flanged and punched.

Boiler Barrel.—The boiler barrel is to be cylindrical and butt-jointed, and is to be made in all respects as shown on drawings; it is to be 11 ft. long between the smoke-box tube-plate and the throat-plate of the fire-box shell, 4 ft. 4 in. outside diameter, and composed of ½-in. plates. The longitudinal joints are to have inner and outer covering strips double riveted, the rivets being placed zigzag. The transverse joint to



BOILER OF ENGLISH EXPRESS PASSENGER LOCOMOTIVE.

DESIGNED BY MR. W. ADAMS, LOCOMOTIVE SUPERINTENDENT OF THE LONDON & SOUTHWESTERN RAILWAY. BUILT AT THE NINE-ELMS SHOPS OF THAT COMPANY.

(For description, see page 59.)

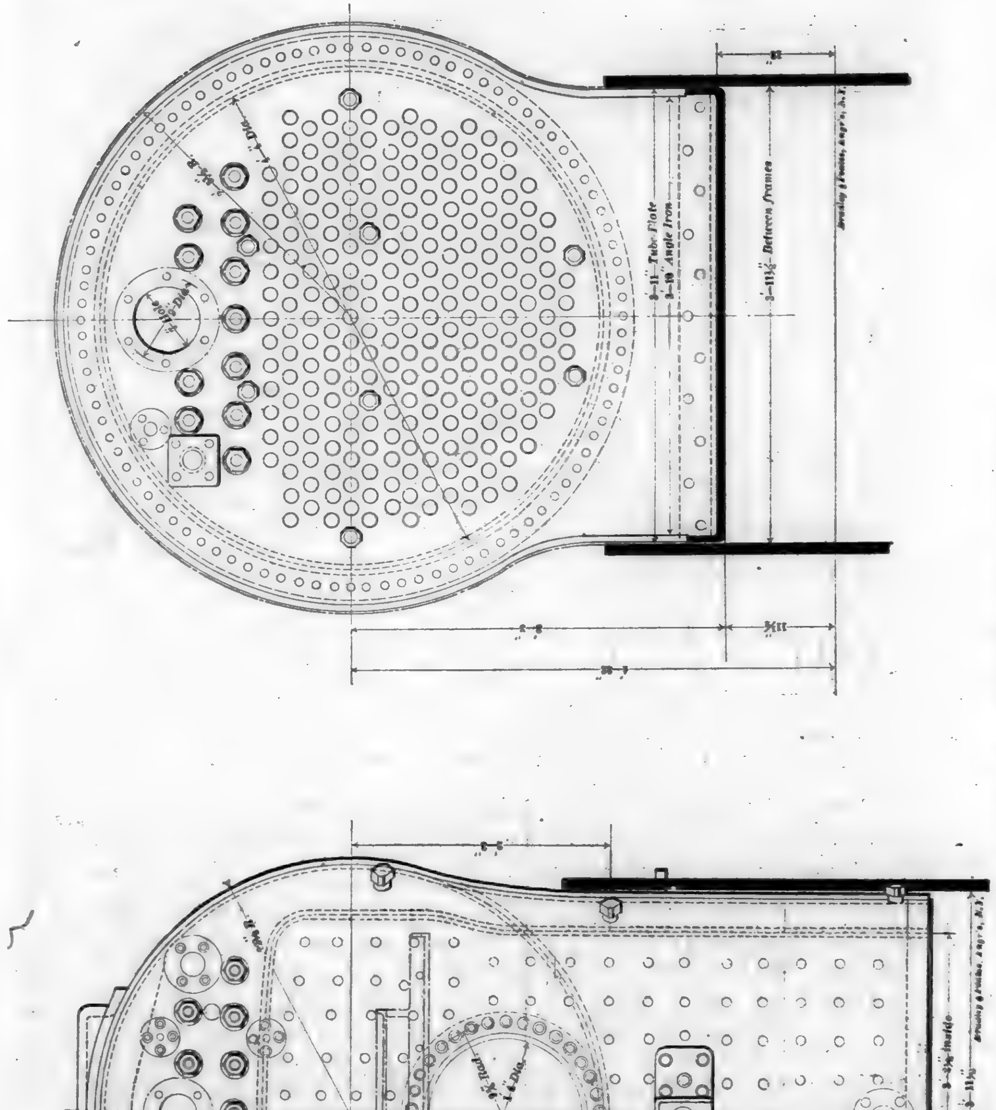


Fig. 5. END VIEWS OF BOILER FOR ENGLISH EXPRESS LOCOMOTIVE.

(For descripti'n, see page 50.)

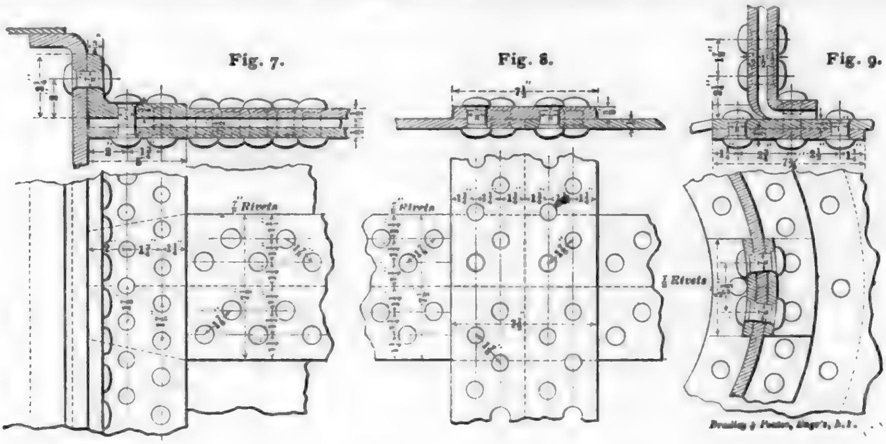


Fig. 7. Fig. 8. Fig. 9.

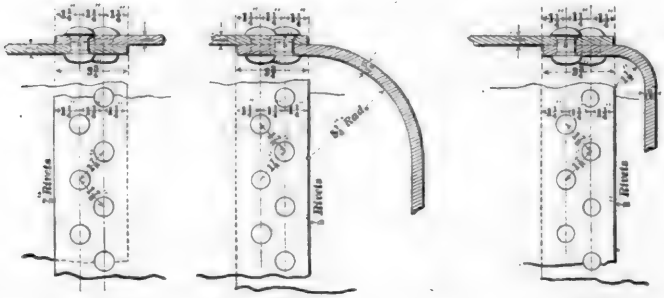


Fig. 10. Fig. 11. Fig. 12.

BOILER SEAMS OF BOILER FOR ENGLISH EXPRESS LOCOMOTIVE.

have an exterior steel weldless ring double riveted. Ring to be turned inside to gauge and to the exact diameter necessary; and then shrunk on. All studs and fittings are to be fixed before the boiler is tested.

Smoke-box Tube plate.—The smoke-box tube-plate is to be ¾ in. thick, the tops and sides of the plate being turned forward 2¾ in., forming a flange for the smoke-box, and is to be secured to the boiler barrel by a continuous weldless ring of angle steel well annealed, and supplied by makers to be approved by the Railway Company's Locomotive Superintendent. The ring must be faced, bored, and turned on the edges, and then shrunk on the boiler barrel, and is to be double riveted to the same, the rivets being placed zigzag. The tube-plate is to be faced where it is joined to the boiler steel angle. Eight wash-out plugs are to be inserted in the plate, as shown on drawing.

Fire-box Casing.—The fire-box casing is to be 6 ft. 4 in. long and 3 ft. 10½ in. wide outside at the bottom, and to be 5 ft. below the center line of the boiler. The top and sides are to be in one plate ½ in. thick. The back plate to be 9/16 in. thick, and flanged over to join the covering plate. The front or throat plate is to be 9/16 in. thick and flanged over to join the barrel.

All riveted joints in fire-box casing to be double riveted. The expansion brackets are to be riveted to the sides of the fire-box shell. The holes in fire-box casing plates for copper stays are to be drilled and then tapped to form a good thread.

Riveting.—All rivet holes to be punched or drilled ¾ in. in diameter, all rivets to be of the best Yorkshire iron with a breaking strength of not less than 22 tons per square inch, and an extension of not less than 30 per cent. in 2 in. Rivets to be 11/16 in. in diameter before being closed, and to be closed wherever possible by a hydraulic pressure of at least 30 tons, so that they properly fill the rivet holes. The holes in the plates are to be slightly countersunk under the rivet heads, and so punched that when the plates are in proper position for riveting the smaller dimensions of the holes shall be together at the center of the joint. All holes in the various plates and angle-irons must be perfectly fair with one another, and must not be drifted in any case; should any of the holes not be perfectly fair they must be rimered out until they become so, and every hole must be completely filled by the rivet. The holes in the angle-irons must be marked from the plates and drilled (not punched), the pitch of rivets and lap of joints being in all cases as shown on drawing. Great care must be taken that the plates are brought well together before any rivets are put in. The edges of all the plates are to be planed before being put together. Any caulking which may be required must be done with a broad-faced tool, care being taken that the plates are not injured by so doing.

Copper Fire-box Plates.—The copper plates to be of the very best quality manufactured, and to be supplied by makers approved by the Railway Company's Locomotive Superintendent, of the exact dimensions, both as regards form and thickness, as given on the drawings.

The copper plates are to be properly annealed, and a piece taken from each plate must stand the following tests, viz.:

The ultimate tensile strain to be not less than 13.5 tons per square inch, with an elongation of not less than 40 per cent. in 2 in.

A piece 6 in. long is also to be bent double when cold, without showing signs of fracture at the heel of the bend.

Tests to be made in the presence of the Locomotive Superintendent of the Company or his Inspector.

Inside Fire-box.—The inside fire-box is to be of copper, 5 ft. 5 3/16 in. long inside at the top, and 5 ft. 7¼ in. long inside at the bottom; the height inside at the middle of the box is to be 5 ft. 9½ in., the width inside at the top, 3 ft. 6 in., and at the bottom, 3 ft. 2½ in. The tube-plate is to be 1 in. thick where the tubes and barrel-stays pass through it; the remaining portion is to be reduced by hammering to ½ in. thick, and is to be flanged back to join the covering plate. The back plate,

which must be ½ in. thick, is to be flanged forward. The sides and top are to be in one plate, and ½ in. thick; the joints are to have 2½-in. lap when finished and to be single riveted with ⅞-in. iron rivets, same quality as used for boiler. All the joints in the copper fire-box are to be hand riveted. Two fusible plugs are to be fixed in the crown of the fire-box.

Fire-hole Door.—The ring for the fire-door is to be of the best Yorkshire iron, and is to be circular and of the dimensions shown on drawing. The ring is to be riveted to the fire-box by ⅞-in. rivets and is to project ¼ in. beyond the edges of the plates, which must be well caulked. The fire-door is to be of cast iron, formed in two halves, and made to slide as shown on drawing. A wrought-iron deflecting plate is to be fixed in the fire-door hole as shown. Also a brick arch in the fire-box as shown.

Stays.—The outside and inside fire-boxes are to be stayed together on all sides with copper stays 1 in in diameter and 12 threads per inch, made from best soft rolled bars, having a breaking strength of not less than 14 tons per square inch, with an extension of not less than 40 per cent. in 2 in. properly annealed, screwed steam-tight into both copper and steel plates and afterward riveted over. Great care must be taken in cutting off the ends of the stays so as not to injure the threads. The pitch of the copper stays to be about 3¾ in. center to center, as shown. Great care must be taken that the holes in the outside and inside boxes are exactly opposite one another. The barrel stays are to be riveted to the boiler with ⅞-in. rivets and secured to the tube plate as shown in the drawing. The inner copper fire-box is to have eight roof stay-bars of cast steel of approved make of the section shown, and secured to it by bolts which are tapped into the stays only as shown on the drawing. The stays are to bear on the top, back and front plates, and are to be slung where shown to the outer shell. The back plate of the fire box casing and the smoke-box tube-plate are to be stayed together with 11 wrought-iron longitudinal stays 1½ in. in diameter where they pass through the back plate, and 1¾ in. in diameter for the remainder of their length; these stays are to have the head bedding on a copper washer and screwed into the fire-box plate; at the other end they are to be secured by a nut bedding on a copper washer on each side of the plate.

Tubes.—The boiler is to contain 240 brass tubes, of a brand and manufacture to be approved by the Railway Company's Locomotive Superintendent. Each tube is to be 1¾ in. outside diameter expanded at smoke-box end to 1⅞ in. outside diameter for a length of 3 in. and contracted to 1⅝ in. outside diameter at fire-box end. Each tube is to be No. 11 standard W. G. thick at the fire-box end for a length of 1 ft., and then to be drawn tapered to No. 13 standard W. G. thick at the smoke-end, the taper being on the inside only, the outside remaining parallel. The proportion for the metal in the tubes to be 70 per cent. best selected copper and 30 per cent. best Silesian spelter. The tubes are to be inspected by the Railway Company's Locomotive Superintendent or his Inspector, and supplied clean, and are not to be covered with paint or any similar coating. The maker's name to be clearly stamped on the outside of each tube. The tubes are to be expanded by a Dudgeon's tube expander, and ferruled at the fire-box end only. At the smoke-box end the tubes are to stand through the plate ¼ in.

Dome.—The steam dome is to be made as shown on drawing, and to be provided with steel cover. The dome is to be 2 ft. 0 in. inside diameter and 2 ft. 2 in. high inside, and ½ in. thick. The dome is to be made in one plate and butt jointed as shown. A strengthening plate ½ in. thick is to be riveted to the inside of the boiler under the dome as shown on drawing. The hole for the dome is to be 19½ in. in diameter. A soft-steel manhole seating is to be single riveted to the center of the fire-box top, and fitted with a cast-iron cover-plate formed in one with the safety-valve columns. The cover-plate and manhole seating are to be accurately faced, so that a perfect steam-tight joint can be made.

Regulator.—In the inside of the dome is to be placed a cast-iron regulator in two parts with flanged joint, to have two valves, main valve of brass and the easing valve of cast iron, to be worked from the back of the fire box. The steam-pipe leading from the regulator to the smoke box is to be of hard-drawn copper, No. 6 standard W. G., 5¼ in. inside diameter, and is to have a brass flange brazed on where it fits into the tube-plate; the other end of the pipe to have a brass collar brazed on, and is to be secured to the stand regulator pipe as shown.

Water Space.—The water space between the fire-box and shell is to be 3 in. wide at the foundation ring, and is to be enlarged upward to the dimensions shown on drawing.

Foundation Ring.—The foundation ring is to be of the best Yorkshire iron, 3 in. wide × 2½ in. deep, and riveted to the inside and outside fire-boxes with ⅞-in. rivets, snap-headed, 2-in. pitch, to the section as shown on drawing.

Ash-pan.—The ash-pan is to be placed below the fire-box casing, with movable doors and perforated dampers at the back and front, so arranged as to be worked from the back of the fire-box. The handles for working the doors are to be placed at a convenient height on the foot-plate as shown. The sides are to be of ¼-in. plates and the bottom of ¼-in. plate, of Best Best Staffordshire iron; angle-irons 2 in. × 2 in. × $\frac{5}{16}$ in. thick are to be riveted to the sides and bottom with ½-in. rivets. The ash-pan is to be of the form, and fixed in the manner shown, by angle-irons 4 in. × 3 in. × ½ in., and cottered pins screwed into foundation rings.

Fire bars and Carriers.—The fire-bars are to be of cast iron of the form and dimensions shown, and the carriers of wrought iron secured to the foundation ring in the manner shown on drawing.

Smoke-box.—The smoke-box is to be of the form and dimensions shown on drawing. The sides and crowns are to be $\frac{5}{16}$ in. thick, riveted to the flange of the smoke-box tube-plate. The front plate is to be in one, and ⅝ in. thick. An angle-iron, 2½ in. × 2½ in. × ½ in. thick is to be riveted to the front and side-plates. A hole for the door is to be cut in the front-plate 3 ft. 10 in. in diameter. The door is to be of Best-Best Staffordshire iron, ⅝ in. thick, protected on the inside with a shield, placed 1⅝ in. from door. Great care must be taken that the door, when closed, is made a perfectly air-tight joint. The cross-bar is to be made to lift out of forged brackets, which are to be riveted to the inside of the front of the smoke-box. Two handles and a gripping screw are to be provided. All the plates are to be clean and smooth, and well ground over. All rivets are to be ⅝ in. in diameter, pitched as shown on drawing, and are to be countersunk and filed off flush. The outside handles are to be finished bright. All lamp-iron brackets are to be fixed as shown.

Chimney.—The barrel of the chimney is to be of good smooth Best Best Staffordshire iron, ¼ in. thick, to have a butt joint, and is to be riveted together with countersunk rivets down the back, having a hoop of half round iron at the top; the bottom is to be of best Yorkshire iron or mild steel plates, ⅝ in. thick, perfectly free from hammer marks, and accurately fitted to the smoke-box. The height of the top of the chimney from rails is to be 13 ft. 2½ in.

Besides the difference in size of the two boilers, a striking feature is the fact that the fire-box of the English boiler is made of copper, whereas the American fire-box is steel. The tubes of the former are brass and those of the latter iron. It is not easy to obtain reliable data concerning the relative economy and durability of copper and steel fire-boxes and of brass and iron tubes. We hope, however, before these articles are completed, to give some figures to show the average endurance of steel fire-boxes and iron tubes, and will try to obtain some similar data concerning copper fire-boxes and brass tubes.

Regarding the construction of the two boilers, the engravings show more than can be told by a verbal description. The longitudinal seams in both boilers have butt joints* with double welt strips inside and outside, as shown in figs. 7 and 21. From the latter figure it will be seen that the welt strip of the American joint is made wide enough to take two extra rows of rivets, which are spaced twice as wide apart as those in the four middle rows.

The barrel of the English boiler, it will be seen, has butt joints at *B*, fig. 3, with a single exterior steel weldless ring outside, the seam being double, or, more properly, quadruple riveted, as shown in fig. 8. The ring is turned inside to gauge and to the exact diameter necessary, and then shrunk on. This is a refinement of workmanship never practised in this country. The corresponding American seam at *D*, fig. 13, is shown by fig. 20, and is simply a double-riveted lap seam. With reference to the relative merits of the two forms of joints, something may be said for each side. Where a butt joint is used the plates are considered to be less liable to corrosion or grooving along the caulking edge. In a butt joint with a single outside welt the plates are probably less liable to grooving than they are in a lap seam, but the welt may and sometimes is corroded and cracked, and such a defect is not discoverable by internal inspection,

* There is a little doubt at the time this was written whether the longitudinal joints of engine 903 are butt joints with double welt strips or lap joints with welt strips inside, and there was no means of deciding it before going to press. The form of seam shown by fig. 21, however, represents the present practice of the Schenectady Locomotive Works.

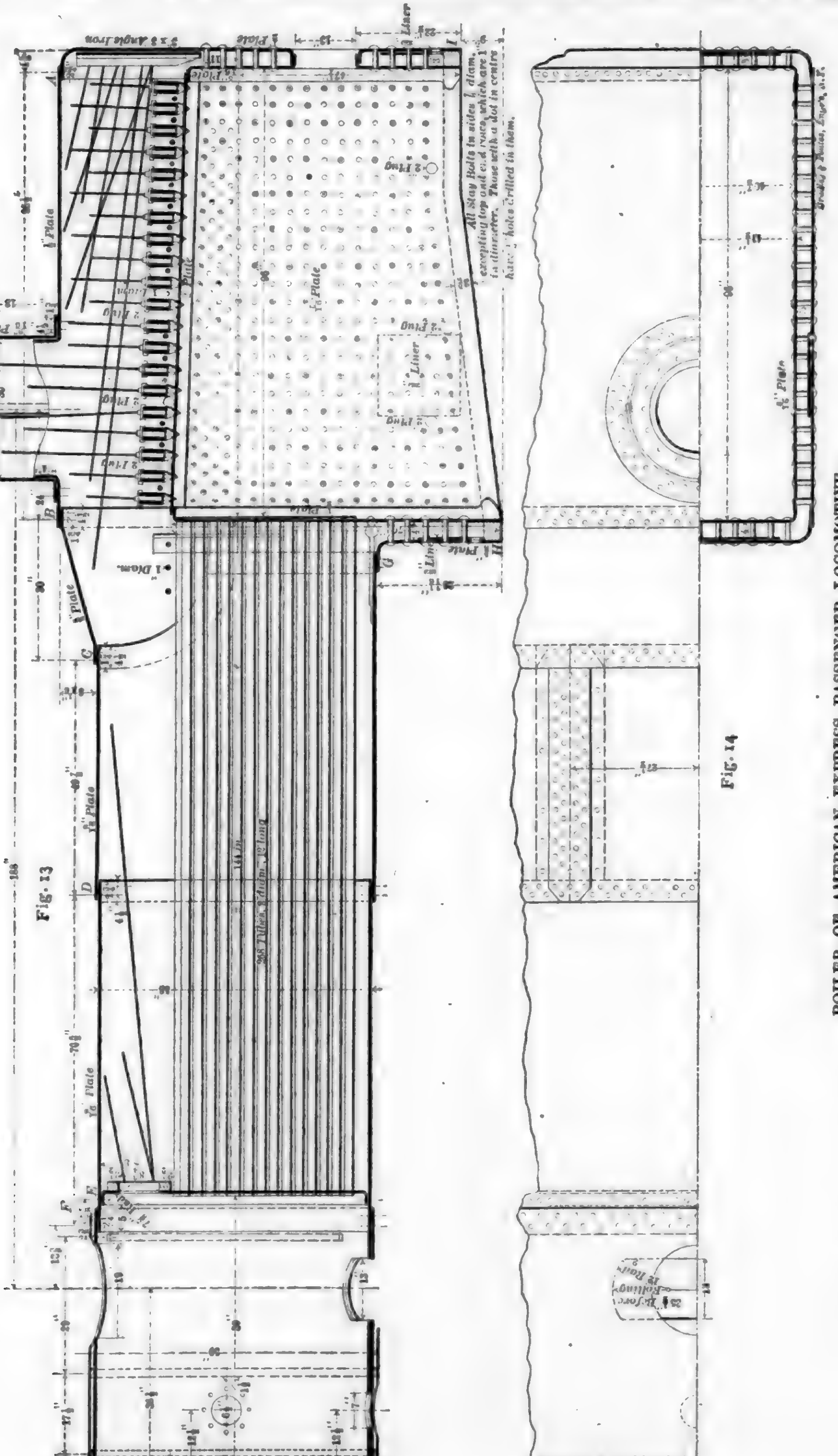


Fig. 13

Fig. 14

BOILER OF AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

DESIGNED BY MR. WILLIAM BUCHANAN, SUPERINTENDENT OF MOTIVE POWER & ROLLING STOCK, NEW YORK CENTRAL & HUDSON RIVER RAILROAD.
BUILT BY THE SCHENECTADY LOCOMOTIVE WORKS, SCHENECTADY, N. Y.

(For description, see page 59.)

Fig. 16.

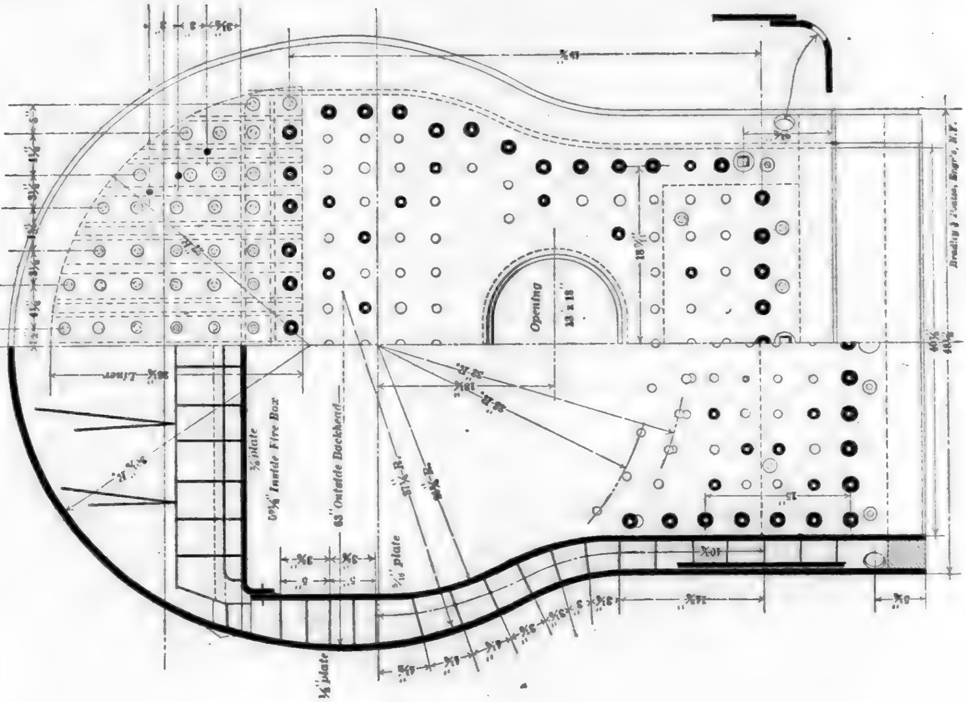
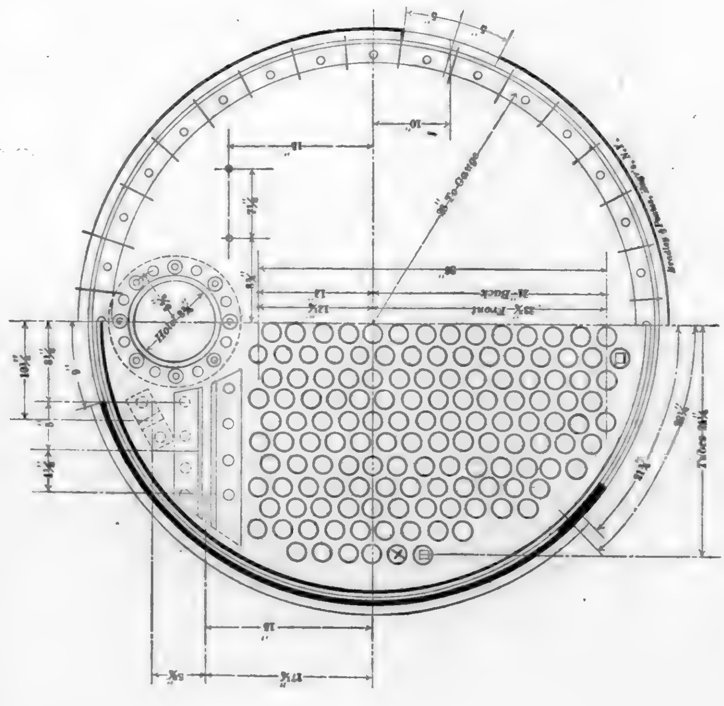
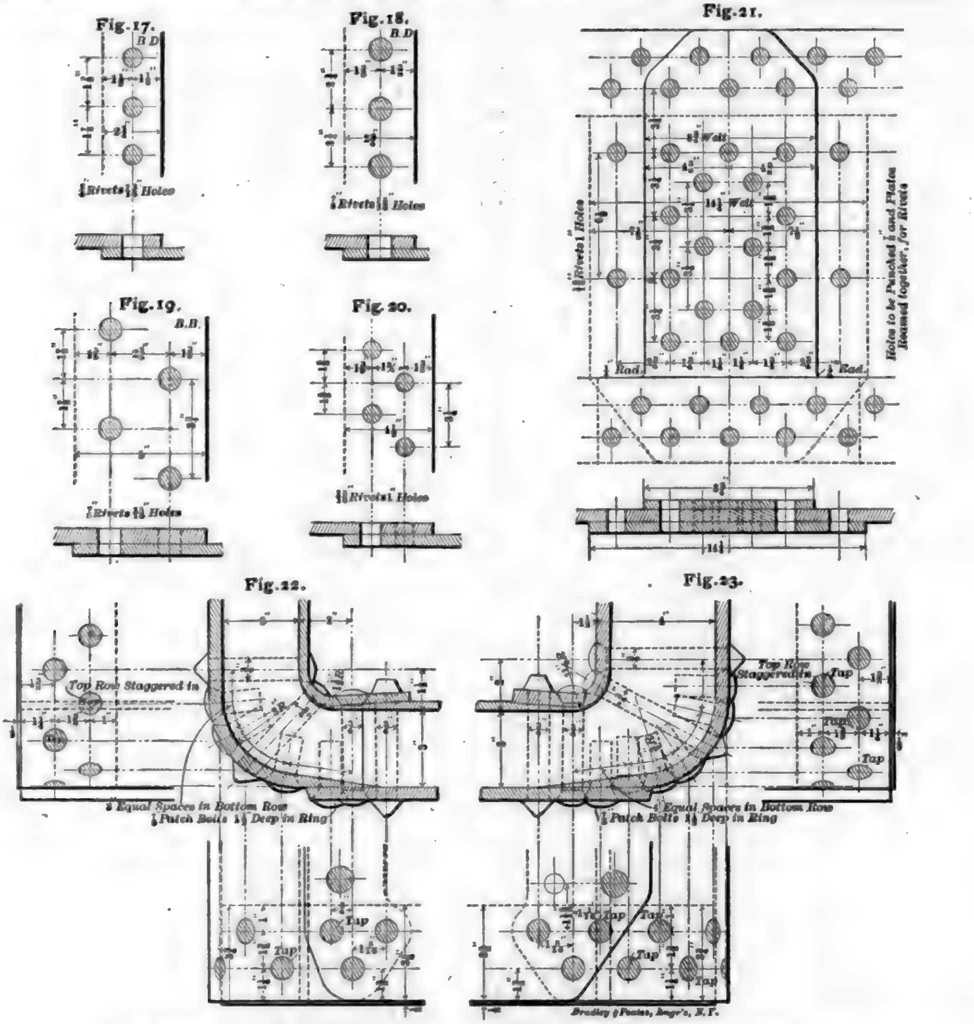


Fig. 15.



END VIEWS OF BOILER FOR AMERICAN EXPRESS LOCOMOTIVE.

(For description, see page 50.)



BOILER SEAMS OF BOILER FOR AMERICAN EXPRESS LOCOMOTIVE.

whereas if the plate in a lap seam is corroded or grooved it can be seen on the inside.

It is true, too, that a weldless ring turned accurately to a gauge and shrunk on a boiler may make a better job than two plates bent to the proper size and merely riveted to each other. But to make a good fit it is as important that the two plates forming the barrel of the boiler on which the ring is shrunk should be made with the same degree of precision as the ring itself if the latter is shrunk on. It is impracticable to turn the plates so that dependence must be placed on the accuracy of the boiler-maker's work. This reliance may be had in fitting the two rings of plates into each other in a lap joint, so that it is doubtful whether very much better work is obtained if the welt ring is turned, shrunk on and quadruple riveted than is possible in a simple lap joint double riveted, and certainly the difference in cost is very materially in favor of the latter form of construction.

The front seams in the fire-box casing are substantially the same in both boilers. The use of a wagon-top over the fire-box makes a gusset plate necessary on top where the casing joins the barrel. The back seam, fig. 18, of the casing of the American boiler is single riveted, whereas that of the English boiler, fig. 11, is double riveted. The English dome has a butt seam, fig. 9, with two rows of rivets, which makes a very good job. The connection of the domes of the two boilers to the barrel in one case and to the fire-box casing in the other it will be seen from figs. 8, 9 and 13 are quite different. A strengthening plate ½ in. thick is riveted to the inside of the English boiler under the dome, and the dome itself is riveted to the boiler and to this ring by a flange and a single row of rivets.

From fig. 13 it will be seen that the fire-box casing of the American boiler is flanged upward at the base of the dome, and another flange is turned outward on the bottom of the dome plate as shown. Each of these flanges take two rows of rivets. It is rare that a dome fails in the vertical seam; and therefore it seems doubtful whether butt seams are needed. The point where they do fail oftenest is in the angle of the flange around the base. It is thought that the method of construction of the American boiler adds more strength to this weak point than the English method does. It is true that the American method does not fully compensate for the material cut out of the casing for the opening at the base of the dome, and therefore a combination of the two methods of construction, it would seem, would be an

improvement over either. The suggestion would be to make a ring of iron or steel of a section of about ¾ × 4½ in. welded or rolled into the form of the tire of a cart wheel, and place it inside of the base of the dome, and let the rivets in the vertical seam pass through the ring and the two plates.

The difference in the method of forming the fire-hole is shown in figs. 3 and 13. In the one case a solid bar or ring is riveted between the inner and outer plates. In the other the two plates are flanged, the one inward and the other outward, and riveted together. The first method has been abandoned here and the other substituted for it. The only difference in the mud or foundation rings is that in the American boiler it is 3¾ in. deep and double riveted, whereas in the other it is only 2½ in. deep and single riveted. The necessity of double riveting this part of large fire-boxes has been made apparent within the past few years, and it is now generally done here in the best practice.

From fig. 13 it will be seen that two extra rows of stay bolts are placed along the upper part of the sides of the fire-box. This is the usual practice on the New York Central Railroad, but is not generally employed elsewhere. The stay-bolts are of iron ⅞ in. in diameter excepting those on the top and end rows on the sides of the fire-box, which are 1 in. in diameter.

The crown-bars or roof stay-bars of the English boiler are made of cast steel and extend lengthwise on top of the fire-box; those of the American structure are made of two bars of wrought iron welded together at the ends, and extend crosswise of the fire-box. With a fire-box 8 ft. long it would be impracticable to place the crown-bars lengthwise. In one as short as 5 ft. 7⅞ in. a good job can be made in the method used by Mr. Adams. In both cases the bars are connected to the casing by sling stays, but of quite different forms and methods of construction.

The relative merits of straight-top and wagon-top boilers have been much discussed in this country. In favor of the first it is said that they give more room for steam over the fire-box and for men to work, and for inspection inside of that part of the boiler. In favor of straight-top boilers it is said that they are stronger and cheaper. At the present time the preponderance of opinion seems to be in favor of wagon tops, although it is thought that their apparent advantages are due more to bad designing of the straight-top form, and to the fact that when wagon tops are used they are usually made considerably heavier than straight boilers. If made of equal weights, it is believed that as good or better results may be obtained with straight as with wagon-top boilers, and with somewhat less cost for the former. On straight boilers the dome should obviously be placed near the middle of their length, because at this point there is less variation in the height of the water and less effort, due to the "swash." If a wagon top is used, the dome may be placed over the fire-box, because the additional height compensates somewhat for the difference due to its position. In fact, wagon tops have often been used because it seems desirable to place the domes over the fire-box.

The longitudinal stays of the one boiler, it will be seen, extend horizontally from the back-head to the front tube plate, whereas in the American boiler they are placed diagonally and attached to the fire-box casing or the barrel of the boiler. The former plan was a very common one here twenty or twenty-five years ago, but has since been generally abandoned. The tremor of the rods, it was found, broke them and caused them to leak when they passed through the heads.

Another point of difference in the construction of the boilers is in the method of attaching the smoke-boxes to the barrel, and in the fact that the smoke-box of the English boiler is made of larger diameter than the barrel. This, it is thought, is an advantage, as it gives more room for steam pipes, etc., inside, and they can thus be kept clear of the tubes. The tube plate is "secured to the boiler barrel by a continuous weldless ring of angle steel well annealed. . . . The ring must be faced, bored and turned on the edges and then shrunk on the boiler barrel, and is to be double riveted to the same, the rivets being placed zigzag. The tube plate is to be faced where it is joined to the boiler steel angle." This, it will be seen, makes a very good job, but is considerably more expensive than the method of construction shown in fig. 13. Whether the advantage of having more room in the smoke-box pays for this extra expense seems a little doubtful.

Regarding the advantages of an extended smoke-box, it may be said that it is comparatively easy at any time to excite an animated discussion thereon among locomotive men in this country, in which each side will be warmly advocated. It is now very generally used, and the idea is held that a locomotive with this attachment is less liable to "throw fire" than without. It is generally admitted, we believe, that locomotives here are worked harder than they are in England. Under these conditions they are more liable to throw fire and thus do damage, especially in our climate, which is drier than that of Great Britain. If, then, an extended smoke-box permits a locomotive to be worked harder without doing damage than it would be without such an attachment, then to that extent it is an advantage. That seems to be the verdict deduced from the general practice in this country.

The specifications say and the drawings show that the holes in the plates for the English boiler are to be slightly countersunk under the rivet heads. This is a decided improvement on American practice, as it is seldom or never done here.

It is difficult to draw any general deductions or make comparisons until all the parts of the two engines have been described, therefore these will be reserved until after all the different parts of the two locomotives have been illustrated and discussed.

We may add that we are further indebted to the Schenectady Locomotive Works and to Mr. Adams for copies of specifications of the engines, from which we have quoted, and expect to use in future articles.

(TO BE CONTINUED.)

SOME CURRENT NOTES.

In his annual message, Governor Flower, of New York, follows the line of his predecessor in urging road improvement, and in advocating State assistance to local communities in building roads.

The Governor of Pennsylvania also refers to the road question at considerable length. He advocates improvements in the road laws and a better system of taxation for road improvements and maintenance.

The difficulty of soldering aluminum, which is believed to result from the formation of a thin film of oxide on the metal, has been overcome by the use of a flux containing a small amount of phosphorus, which serves to deoxidize the surface and leave it clean. This solution was discovered by Mr. Joseph Richards, of Philadelphia.

In his recent message to the Legislature, Governor Flower, of New York, urges very strongly the necessity of preserving the Adirondack forests for the general benefit of the State, and refers to the great injury which may be done by any further indiscriminate cutting or clearing of the woodland in that region. His warning is a timely one, and should be heeded.

On the Austrian railroads considerable attention has been given to planting trees along the slopes of the railroad cuts and banks, and in other places where there is room on the right-of-way. In some places these are intended to act as wind-breaks and defenses against snow; in others they are simply to utilize the waste land. A recent statement shows that these plantations, as reported up to date on the various lines, include about 370,000 fruit trees of various kinds—plum, pear, apple, peach, apricot and others—and about 3,600,000 forest trees. Some of the latter, such as willows, are planted chiefly on account of the use of their roots in preserving and consolidating slopes; others—oak, fir, pine, larch, etc.—will be valuable in due time as timber. These plantations are being extended each year.

On January 1 there were, according to the *American Manufacturer's* tables, 250 furnaces in blast, capable of a

total weekly production of 175,701 tons of pig iron; an increase of a little less than 1 per cent. during December. The capacity of the furnaces in blast, however, is less by 15,741 tons, or 8 per cent., than it was on January 1, 1892, although it is greater than is shown by the report for any month since April. The tendency for several months past has been to a slight but steady increase.

The *American Manufacturer* also estimates the total production of pig iron for 1892 at 9,139,711 tons; an increase of about 10½ per cent. over 1891, but a decrease of 1 per cent. from 1890. The year 1892, however, shows the largest production—with the exception of 1890—of any year in our history.

The big lifting bridge over the Harlem River on the New York Central & Hudson River Railroad, which was described some time ago in our columns, was successfully moved recently to a point some 60 ft. west of its original location. The moving of the great tower—127 ft. high and weighing 180 tons—was actually completed in 21 minutes; but the preparations for the work occupied several days. The removal was made necessary by the fact that a new bridge will have to be built in connection with the raising of the tracks across the Harlem.

According to the statements prepared by the *Railway Age* there were 4,062 miles of new railroad built in 1892—less than in any year since 1885, but still an appreciable addition to the railroad system of the country. The activity in construction was greatest on the Pacific Coast and in the South, although there was a fair amount of work done in Ohio, Indiana and Michigan, and more in New York and Pennsylvania than for several years past. A large proportion of the new mileage was in short lines and branches.

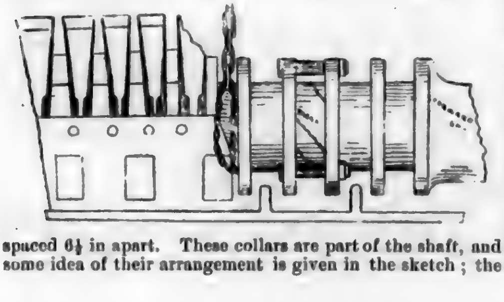
The truck for long passenger cars is considered a necessity by Mr. Dundas, President of the Institution of Engineers & Shipbuilders in Scotland. He does not consider the radial axle a satisfactory device.

The latest use of aluminum is for slate-pencils. Major von Sillich found that the metal would mark on slate, and the pencils are now made by a German company. They need no pointing, will not break and will last a long time.

In a recent lecture in Sheffield, England, Professor Ripper stated that, in spite of the great improvements made, our present engines and boilers utilize only from 4 to 6 per cent. of the total heat generated. Chimney draft alone cost from 20 to 30 per cent. of the fuel burned, and other losses were found everywhere.

The longest balloon trip on record, it is claimed, was made in October last by M. Maurice Mallet. In his balloon, which he has named *Les Inventions Nouvelles*, he ascended from La Villette, near Paris, on October 23, and ended his voyage on the following day at Walhen, in Germany, having been in the air a little over 36 hours.

Most of our readers have probably seen in the daily papers some account of the accident to the Cunard steamer *Umbria* and its repair in mid-ocean; but a brief account will not be out of place here. The main shaft broke in the thrust bearings where the body of the shaft is 25 in. in diameter, with collars 36½ in. in diameter and 3¾ in. thick,



spaced 6¼ in apart. These collars are part of the shaft, and some idea of their arrangement is given in the sketch; the break was between two of them, as is also shown. The method of repair adopted was to use two adjoining collars as flanges of a coupling, connecting them by three 5-in. steel bolts. To do this grooves had to be cut in the two collars large enough to take the bolts; the bolts had to be cut to the proper length; the nuts had to be cut down, as they were too large to enter the space; and bands had to be placed around the shaft to hold the bolts in place. The difficulties attending this work at sea, with only the hammer and cold chisel, and in the limited space around the shaft, can be imagined.

The new elevated railroad which runs along the water front of Liverpool a distance of about six miles, is to be operated by electricity. The power station is near the middle of the line, and contains three groups of dynamos, each operated by a 400-H.P. engine. The current is carried by steel bars placed between the rails on porcelain insulators. The cars will be run in trains of two or three, as may be needed, at a speed of 12 miles an hour. Each car will seat 56 persons.

The production of copper in the United States in 1892 is estimated by the *Engineering and Mining Journal* at 325,180,000 lbs., of which 107,200,000 lbs. were from the Lake Superior region and 104,300,000 lbs. from Montana mines. The total is an increase of about 13 per cent. over 1891. Exports diminished slightly, but there was a large increase in the home consumption, so that the stocks on hand at the close of the year were considerably less than at the end of 1891.

The New York Railroad Commission, in its latest report, refers to the lighting of passenger cars as follows: "Success has attended the effort to light passenger cars with gas. Last year the Board set on foot inquiries as to the practicability and safety of the various systems in use, and the answers were assuring in both respects. Indeed, so practical and so successful are the systems, and so widely have they been adopted, that a car in one of the first-class or limited trains lighted by oil would be regarded as a relic of a past age. A sufficient reason why every passenger car, whether a palace or ordinary coach, should not be lighted by gas cannot be given. Economy should not be the prevailing consideration. Aside from the increased security from fire, the annoyance of dripping oil from the lamps is avoided. The lighting of all passenger cars with gas is in line with the progress which has led to heating by steam instead of stoves, and which is leading to automatic couplers instead of the link and pin, coupled by hand, and automatic brakes set from the engine rather than by men on the tops of the cars at the risk of their lives. The prohibition of the use of oil by legislative enactment is desirable."

THE COLUMBIAN EXPOSITION.

From time to time references have been made to the progress of work on the buildings at Chicago, but we now present for the first time a plan showing the general arrangement of the grounds and the position of the buildings; for this cut we are indebted to the courtesy of the *Street Railway Journal*.

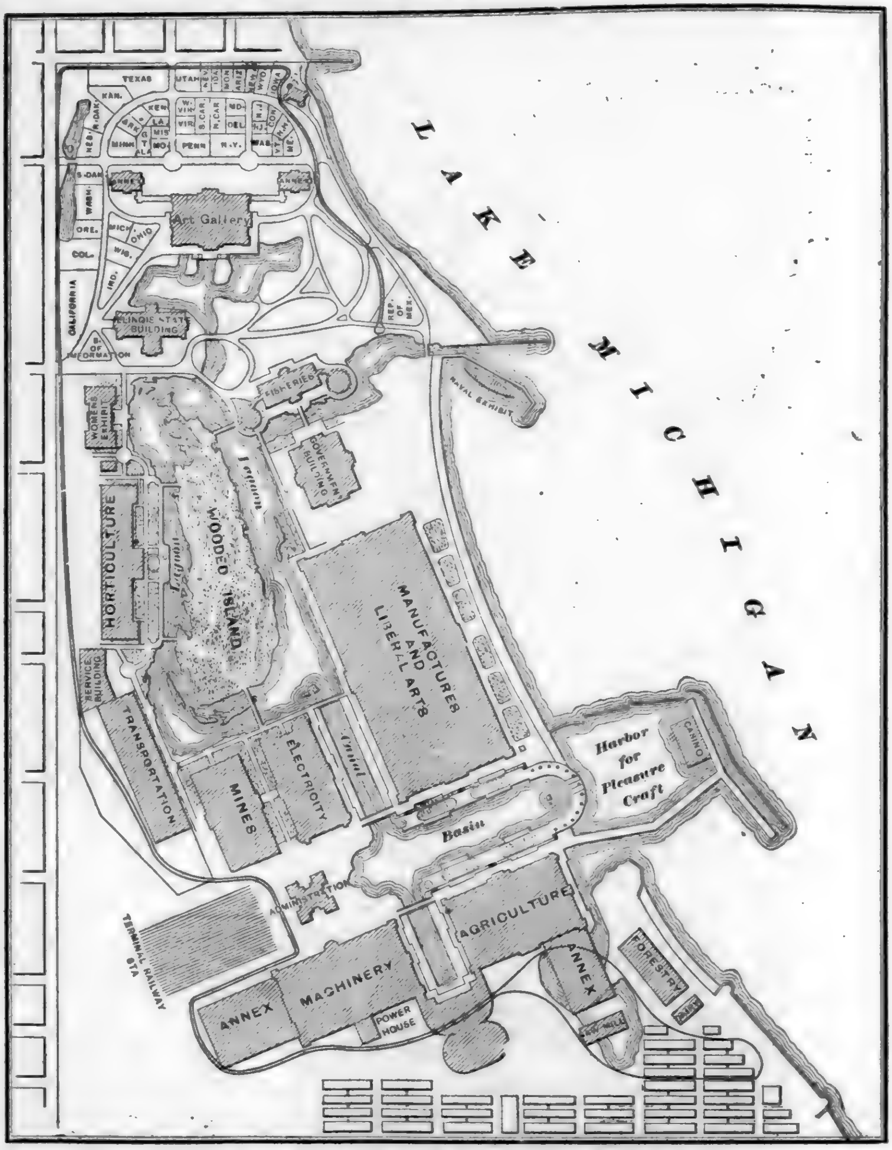
This plan designates all the chief buildings by name; but no map that could be given within the limits of our page could show them all in this way. We hope, however, to give hereafter fuller plans in which more detail will be possible.

The grading and reclamation of Jackson Park is now substantially completed, and most of the buildings are in a condition where little but the finishing work remains to be done. The progress made with the work is extraordinary, when it is remembered that the designs were not finally completed or adopted until the winter of 1891, and work was not fairly begun until the next spring.

At the time of the opening in October, it was stated that only the decorative work remained to be done, and this statement was substantially correct. In fact, the work of putting in the exhibits was begun soon after, and is now going on.

The great size of the principal buildings is shown by the plan, but will be better understood from some of the figures given. The main buildings have an area of about 5,500,000 sq. ft.; the smaller buildings, 1,155,000 sq. ft.; State buildings, 420,000 sq. ft.; foreign buildings, 300,000 sq. ft.; concession buildings, 1,000,000 sq. ft.; making a total of about 192 acres under roof.

The total space available for actual exhibits is about 3,000,000 sq. ft., of which about 1,300,000 sq. ft. have been allotted to foreign countries, and the remainder to American exhibitors. The applications for space amounted to about two and one-half times that actually available, so that the awards were necessarily much less than was asked for.



PLAN OF THE COLUMBIAN EXPOSITION GROUNDS.

It may be added that great precautions have been taken against fire. Mains are laid all over the grounds, and fire-engines are provided, besides connections with the city fire department, and a boat provided with powerful pumps will be kept on the water front.

The size of the buildings and the distances between them will doubtless dispose visitors to use liberally such means of transportation from one part of the grounds to another as are provided. The first of these is the electrical elevated railroad, which makes a circuit of the grounds, starting from a point near the Agricultural Building at the south end, passing as close as possible to all the principal buildings, and having its loop or terminal circuit near the north end of the Manufactures and Liberal Arts Building. Stations are placed at convenient points, and the road can be used by visitors either to make a complete circuit of the grounds or to pass from one point to another. The total circuit made by this road is about five miles.

Transportation by water will also be available, canals having a total length of 2½ miles having been laid out in the grounds; on these a large fleet of electric launches will ply, carrying passengers from point to point in the grounds. Some of these boats will make a round trip without stops; others will stop at the landings adjoining each building, while a third class will be ready for hire by the hour.

On the Midway Plaisance, which may be called the central avenue of approach to the fair grounds, and which is about a mile in length, the Giffard hydraulic or sliding railroad, which has been described in our columns,* will extend the whole length of the avenue, with stopping-places at convenient points.

Finally, the long pier extending into the lake can be

* See number for October, 1889, page 486.

traversed on the movable sidewalk which will be placed there, and upon which passengers can step at any point, leaving it also when they wish.

There are four principal methods of transportation provided for carrying passengers over the considerable distance between the central part of the city and the park where the buildings stand. These are the street cars, horse and cable lines; the elevated railroad; the Illinois Central Line; and steamboats on the lake. The street car and elevated lines are busily engaged in increasing their facilities for carrying passengers, and the Illinois Central has provided four additional tracks for the fair traffic; but its carrying trade will, of course, be limited by the fact that trains can only start from its terminal station on the water front, and cannot reach all parts of the city, as the cable lines do. The elevated road will have the advantage of the street cars in speed. The terminal station at the fair grounds is spacious and as convenient as possible; but to many observers it seems unfortunate that the parallel track system has been adopted instead of the loop plan, which has showed its advantages at the Philadelphia Centennial Exposition and elsewhere.

Another method of travel, which will doubtless be popular, in summer at least, will be by water. Arrangements are being made for a fleet of boats to run from a pier on the city front to the pier at Jackson Park. It is expected that boats enough to carry 15,000 persons an hour will be provided, and the number handled can be increased if it is found necessary.

The transportation problem will be, however, one of the most difficult in connection with the Exposition, and to avoid all inconvenience and crowding will doubtless be quite impossible.

DOWN-DRAFT FURNACES FOR STEAM BOILERS.

FIG. 1 represents a section of a furnace for a steam boiler having a down-draft grate combined with a sort of supplementary up-draft grate or platform below. *A* is the boiler, *C C* are what the inventor calls "manifold dependent water spaces," which are connected together by water-grate

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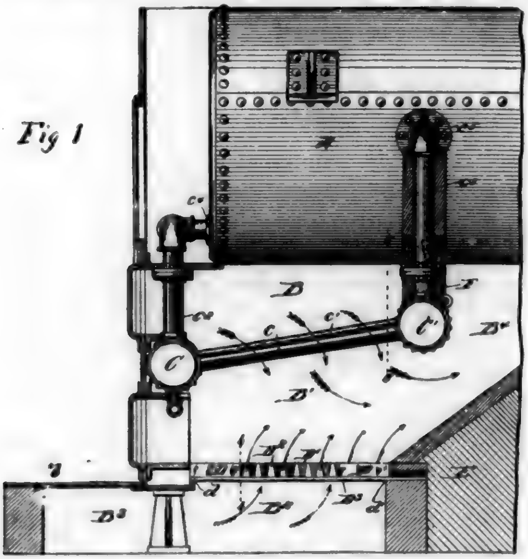

bars *c c'*. The raw coal is fed in on top of these grate-bars. *D*[a] is a supplementary up-draft grate or platform composed of fire-brick or other refractory material having perforations; its purpose being to receive the incandescent coals that fall from the upper grate and retain them for combustion. The course of the draft is indicated by the arrows, fresh air being admitted above the upper grate and below the lower one. The latter current is heated in passing through the lower grate and thus acquires a high temperature, to promote combustion, when it meets and mingles with the air which has passed through the upper grate.

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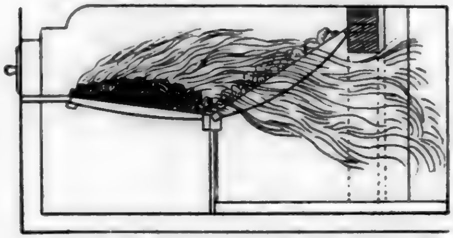

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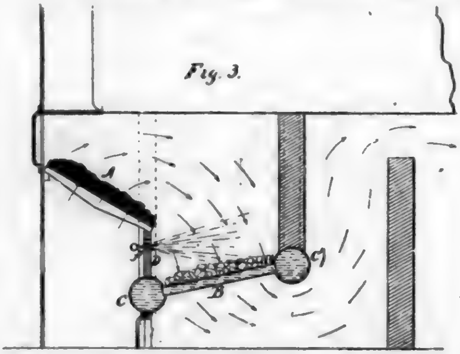

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The locomotive is of the four-cylinder type, with the cylinders placed in tandem, the high-pressure and low-pressure pistons acting on the same rod. The steam from the high-pressure cylinder passes through an intermediate receiver in the smoke-box into the low-pressure cylinder on the opposite side, and steam from the boiler can be admitted

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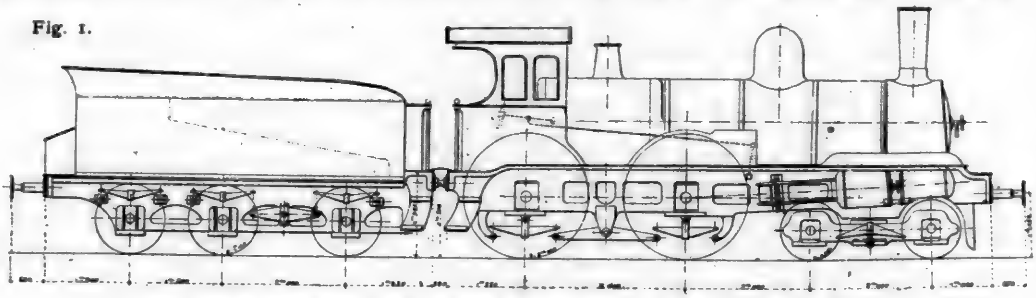

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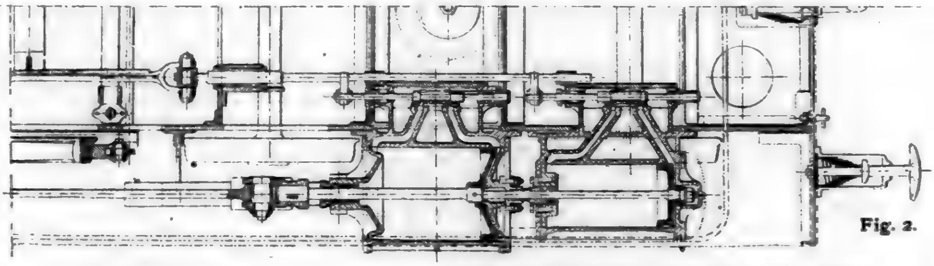

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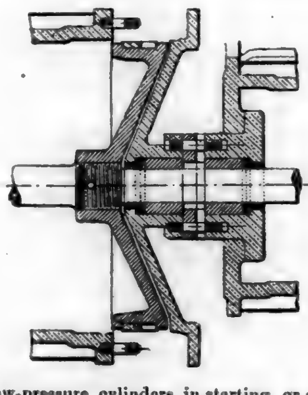

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to the low-pressure cylinders in starting, or at other times when it may be necessary, the apparatus being controlled by the engineer.

The boiler of this engine has a barrel 49¼ in. in diameter, with 208 tubes 1.77 in. in diameter and 12 ft. 6 in. long. The grate area is 20.4 sq. ft. ; the heating surface is : Fire-box, 111 9 ; tubes, 1,205.1 ; total, 1,317.0 sq. ft. The usual working pressure is 165 lbs.

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The driving-wheels are 6.56 ft. in diameter and the truck wheels 3.12 ft. The distance between the driving axles is 8.53 ft., and the truck axles are 6.56 ft. apart. The total wheel-base is 21.65 ft. The total weight of the engine in working order is 94,800 lbs., of which 57,300 lbs. are carried on the drivers. The tender will carry 3,900 galls. of water and 11,000 lbs. of coal, and its total weight when full is 77,100 lbs. The total weight of the engine and tender is thus about 86 tons.

The high-pressure cylinders are 13 in. in diameter and the low-pressure 19.7 in., all being 23.6 in. stroke. The ratio of the cylinders is 1 : 2.30.

The fire-box is of steel and is of the Belpaire type. The engine has Westinghouse brakes, including driver brakes.

Some trials of this engine were recently made by a commission consisting of Mr. de Borodine, Mr. Koribout-Dachkevitch, Engineer-Counsellor of the Department of Railroads, and Assistant Inspector Tichmeneff. From reports presented to this Commission it appeared that the engine had been in regular service on the Kieff-Kasatine Division of the road for nine months, and that it had worked satisfactorily in every respect. The maximum grades on this division are 0.8 per cent., and there are numerous curves. Over this line the engine had frequently hauled a train of 15 six-wheeled carriages, weighing in all 14,700 poods—264 tons—and made regular time. With the ordinary engines in service, two locomotives are usually required when the train consists of more than eight carriages.

Two special trial trips were made by the Commission. On the first the engine, with a train of 15 carriages, made the run from Kieff to Kasatine, 98 miles, making nine stops, in 191 minutes, or at an average speed of 30.75 miles an hour. One of the stops was of 12 minutes' duration. On a grade of 0.8 per cent. a speed of 21 miles an hour was maintained ; and on a descending grade the maximum speed of 46.4 miles an hour was attained. Observations taken during the run showed a variation in boiler pressure from 135 to 165 lbs. The fuel used was coal from the Bogodonhoff mines in the Don District, of which there was burned 3,253 lbs., or 33.2 lbs. per mile run. The report states that 1 lb. of this coal vaporized 8.68 lbs. of water. Diagrams

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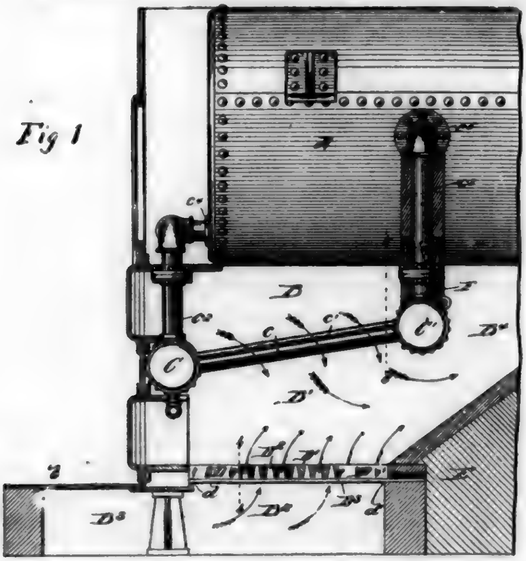

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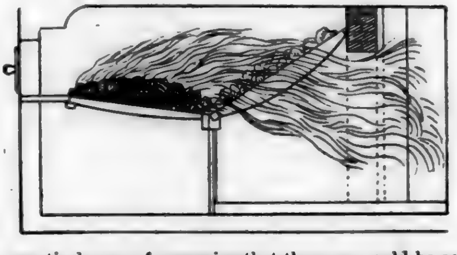

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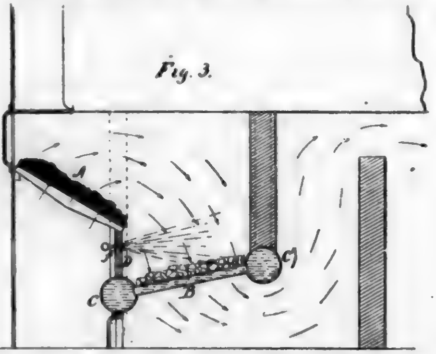

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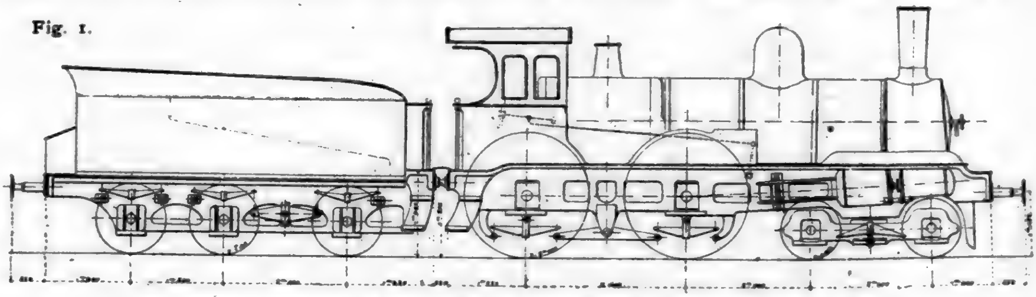

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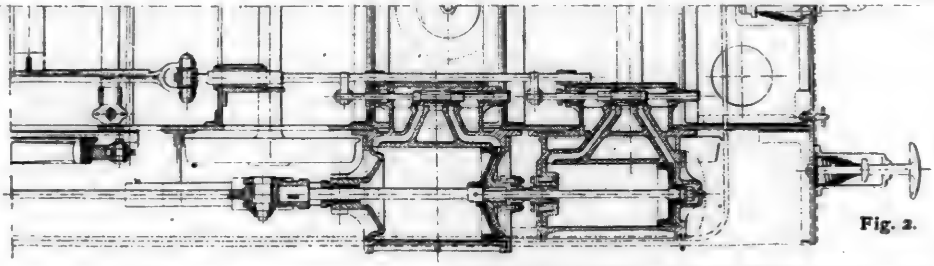

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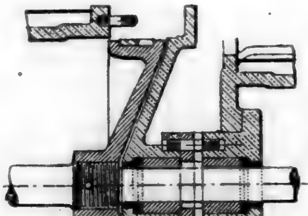

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The fire-box is of steel and is of the Belpaire type. The engine has Westinghouse brakes, including driver brakes.

Some trials of this engine were recently made by a commission consisting of Mr. de Borodine, Mr. Koribout-Dachkevitch, Engineer-Counsellor of the Department of Railroads, and Assistant Inspector Tichmeneff. From reports presented to this Commission it appeared that the engine had been in regular service on the Kieff-Kasatine Division of the road for nine months, and that it had worked satisfactorily in every respect. The maximum grades on this division are 0.8 per cent., and there are numerous curves. Over this line the engine had frequently hauled a train of 15 six-wheeled carriages, weighing in all 14,700 poods—264 tons—and made regular time. With the ordinary engines in service, two locomotives are usually required when the train consists of more than eight carriages.

Two special trial trips were made by the Commission. On the first the engine, with a train of 15 carriages, made the run from Kieff to Kasatine, 98 miles, making nine stops, in 191 minutes, or at an average speed of 30.75 miles an hour. One of the stops was of 12 minutes' duration. On a grade of 0.8 per cent. a speed of 21 miles an hour was maintained; and on a descending grade the maximum speed of 46.4 miles an hour was attained. Observations taken during the run showed a variation in boiler pressure from 135 to 165 lbs. The fuel used was coal from the Bogodonhoff mines in the Don District, of which there was burned 3,253 lbs., or 33.2 lbs. per mile run. The report states that 1 lb. of this coal vaporized 8.68 lbs. of water. Diagrams

taken at a speed of 39.8 miles an hour showed that the work done was equivalent to 588 indicated H.P. At stations the engine started easily and quickly, and it kept steam well.

The return trip from Kasatine to Kieff was made with 11 carriages of a total weight of 11,400 poods, or 206 tons. On this trip also nine stops were made, including two of 14 minutes each and one of 6 minutes, and in addition an extra stop of 4 minutes was made near Tchernoroudka, on account of the rupture of an air-brake pipe. The water vaporized was 9.26 lbs. to 1 lb. of coal, and the coal consumption was 25.8 lbs. per mile. The speed was greater than on the first trip, the average being 40.5 miles an hour, and the maximum 56.4 miles an hour.

It may be added that during its nine months of regular service previous to the tests the engine had run 18,905 miles, an average of 2,101 miles a month. The report of the Commission was very favorable to the new type.

GEODETIC WORK IN FRANCE.

(Translated from *Le Revue Scientifique.*)

At a recent meeting of the Academy of Sciences of Paris, M. Bassot presented some facts in relation to the new meridian established in France. It was some years ago admitted that the meridian of Delambre & Mechain, notwithstanding its great value a century ago, did not agree with recent geodetic measurements made in other countries, and a new measurement of this fundamental meridian was ordered in 1869 and begun in 1870.

For 12 years this work was carried on under the direction of General Perrier, with the assistance of MM. Bassot and Defforges; since 1882 it has been under the direction of M. Bassot, with M. Defforges as Chief Assistant. The work is now nearly completed. It may be added that the manner in which it has been done and the results obtained reflect great credit upon the officers in charge. The general statements are as follows:

1. Starting from the base of Paris the measurements were verified at Perpignan, after passing through a distance of about 6°, and agreed within about 1-250,000, with the new measurements of the base.

2. On the lines or sides of the triangulation common with the English, Belgian and Italian triangulations, the French results are almost identical with the foreign results deduced from the new stamp of the *toise* of Bessel; but on the Spanish side there is a difference of 1-65,000, which is not yet explained.

3. In calculating anew the total of the parallel lines and meridians of the French system, the fact has been recognized that the new meridian restores order and harmony among most of the triangulations. It has not, however, done away with the discrepancies noted by the geodetic engineers in the southwest, in the lines adjoining the Bordeaux and Gourbera bases. For this reason the Geographic Service has submitted to the Ministry of War a plan for the immediate renewal of the mean parallel, as a complement to the new meridian.

4. The length of the meridian line between the extreme astronomic stations, the length of which is about 8° 17', is less by 5 meters only than the arc intercepted on the ellipsoid of Clarke, the flattening, or departure from an ellipse, of which is 1 : 293.46. This shows that, taken altogether, the French arc is almost exactly the same as that of this ellipsoid.

5. The two stations which can be identified with those of the old meridian are Dunkerque and Carcassonne. The new arc between those stations exceeds the arc of Delambre by 44.7 meters, or about 1-20,000.

6. The geodetic co-ordinates have been calculated by starting from the base co-ordinates of the Pantheon, as newly determined by the Geographic Service, and by applying the line to the ellipsoid of Clarke, on hypothesis which has been justified by the facts given above.

7. The comparison of these calculated co-ordinates with the direct co-ordinates has been made at five stations, where the observers determined three elements—longitude, latitude and azimuth. According to a theorem of Laplace there exists a relation between the astronomic longitudes and azimuths and the same elements calculated geodetically, which ought to be verified if the observations are good, whatever the local attractions may be. In each of the five stations where the comparisons were made this equation of condition was satisfied within a limit of less than 1"—a remarkably close result.

To sum up, there is no doubt that the results furnished by this new meridian may be considered as presenting all the certainty attainable in a work of high precision.

A HORIZONTAL COMPOUND ENGINE.

The illustrations given, from *Industries*, show a compound engine of a somewhat peculiar type, built by the Maschinenbau Actien Gesellschaft, of Nürnberg, Germany. Fig. 1 is a longitudinal section through the high-pressure cylinder; fig. 2 a transverse section and fig. 3 a sectional view of the low-pressure cylinder and valve.

In this engine the steam from the boiler is led into the high-pressure steam jacket, where, after circulating around the cylinder, it is admitted into the cylinder covers. The admission valves are placed in the cylinder covers. They are of the central equilibrium type, each embracing a casting which forms an internal prolongation of the stuffing-box. The valves are worked by small rods projecting out parallel with the piston rods, and worked by rods controlled by trip gear. The high-pressure trip gear has the cut-off adjusted by the speed governor. The exhaust valves are also somewhat peculiar. They are of the gridiron type, and are actuated from the outside—that is to say, from the receiver side of the valve, being worked by a slide rod with two projectors, which passes through the exhaust chamber below the cylinder. This rod is worked by a rocker, which is actuated by the lower slipper of the cross-head: In fact, the gear we are accustomed to see on small pumps is here applied to a large engine. From the high-pressure cylinder the exhaust passes to the receiver. This is jacketed with high-pressure steam direct from the boiler. The receiver steam then circulates around the low-pressure cylinder, and afterward passes to the low-pressure valves, which are arranged as in the high-pressure cylinder, except that the governor has no action on the low-pressure trip gear, the cut-off being altered by hand. A condenser is used when convenient.

The cylinders are 15 in. and 22½ in. in diameter by 27½ in. stroke. In ordinary work the engine is run 70 revolutions per minute, and is supplied with steam at 100 lbs. pressure. When, with this initial pressure, the steam is expanded to twelve times its volume, the engine develops 80 H.P., and when expanded seven times it develops 120 H.P. The fly-wheel weighs about 4 tons, and is 11 ft. 6 in. diameter.

This engine was shown at the late Frankfort Electrical Exhibition, where it drove a Lahmeyer dynamo, which was utilized for transmitting power for pumping water for the fountains.

RAILROAD STATISTICS.

The Fourth Statistical Report of the Interstate Commerce Commission, prepared by its Statistician, has just been submitted. It comprises a text of about 100 pages, and contains many important summaries and comparisons pertaining to the operations of railroads. The report covers the fiscal year ending June 30, 1891, and its main points are well given in the excellent summary sent out by the Commission.

MILEAGE.

Railroad mileage in the United States on June 30, 1891, was 168,402 miles. This figure indicates the length of single track mileage, the total mileage of all tracks being 216,149 miles. The length of single track per 100 square miles of territory, exclusive of Alaska, was 5.67 miles, and the length of track per 10,000 inhabitants was 26.29 miles. Some of the States are exceptionally well provided with railroad facilities, as may be seen by the table of the report which shows the length of line in the several States per 100 square miles of territory. Such assignment shows for Con.

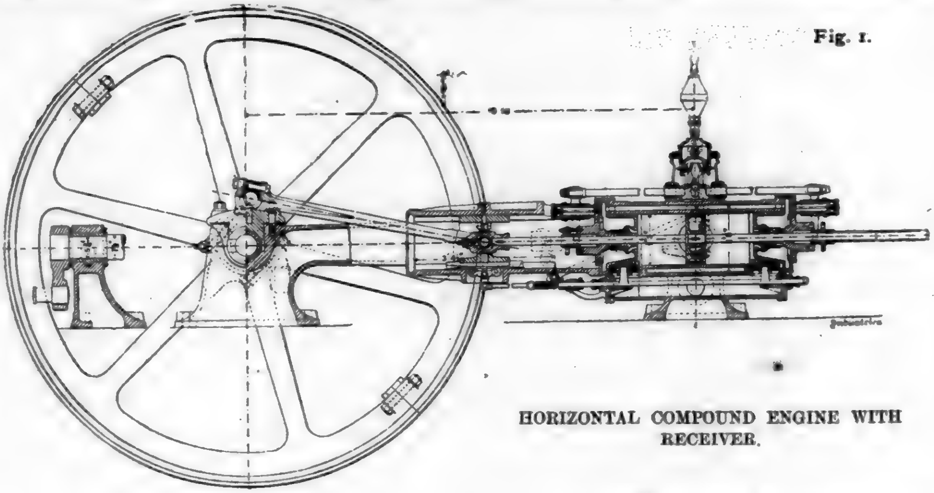


Fig. 1.

HORIZONTAL COMPOUND ENGINE WITH RECEIVER.

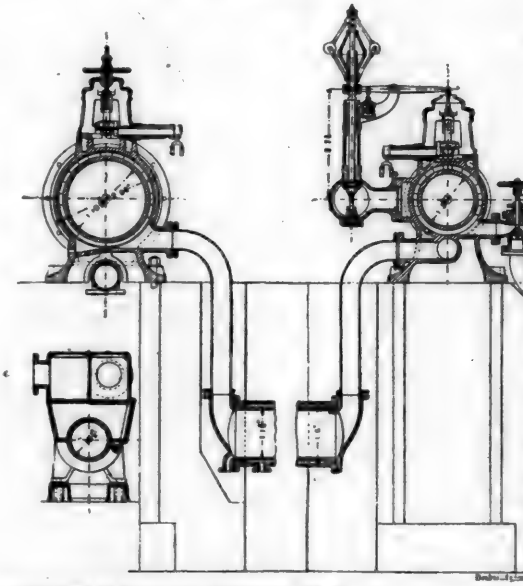


Fig. 2.

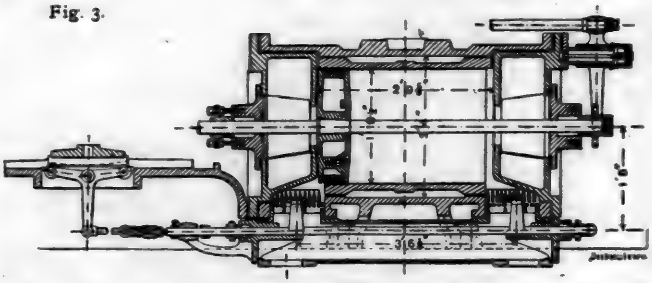


Fig. 3.

necticut 20.77 miles; for Delaware, 16.10 miles; for Illinois, 18.25 miles; for Iowa, 15.12 miles; for Massachusetts, 25.99 miles; for New Jersey, 27.71 miles; for New York, 16.19 miles; for Ohio, 19.68 miles; for Pennsylvania, 22.77 miles. The only countries in Europe which have an excess of 10 miles per 100 square miles of territory are Germany, with 12.77 miles; Great Britain, with 16.52 miles; France, with 11.23 miles; Belgium, with 28.71 miles; Holland, with 13.83 miles, and Switzerland, with 12.43 miles. No country in Europe, Sweden alone excepted, has 10 miles of line per 10,000 inhabitants; while in this country, on the other hand, but two States have less than 10 miles per 10,000 inhabitants.

The increase in mileage during the year was 4,805 miles. This is less than the average of increase for several years past. The greatest activity in railroad building seems to have been in the States lying south of the Ohio and east of the Mississippi rivers, the total increase in these States being 1,670 miles. The steady increase of mileage in the Southern States during a year when there was general quiet in railroad building in the other parts of the country indicates a healthy development.

ORGANIZATION OF RAILROADS.

There were, at the close of the year, 1,785 railroad corporations, of which 889 were independent companies for the purpose of operation, and 747 were subsidiary companies, the remainder being private lines. The report further shows that 16 roads have been abandoned during the year, and that 92 roads, representing a mileage of 10,116, have disappeared by purchase, merger or consolidation. The actual number of railroad corporations in 1891 is less than the number which existed in 1890, notwithstanding the fact that a considerable number of new lines were chartered during the year. The tendency toward consolidation is clearly indicated by the report. On June 30, 1891, there were 42 companies, each of which controlled a mileage in excess of 1,000 miles, and nearly one-half of the mileage of the country is the property of these 42 companies.

Another classification contained in the report shows that there are 80 companies, each of which has a gross revenue in excess of three millions of dollars. The railroads of this class control 69.48 per cent. of the total mileage of the country, receive 82.09 per cent. of the amount paid by the public for railroad service, and perform 83.76 per cent. of the total passenger service and 82.66 per cent. of the total freight service of the country. Out of a total of 81,073,784,121 tons of freight carried one mile, the railroads in question carried 67,008,448,436. Such figures as these in-

dicate the extent to which concentration of railroad control has proceeded in the United States.

EQUIPMENT.

The total number of locomotives used was 32,139, showing an increase of 1,999 during the year; and the total number of cars, the property of railroads, was 1,215,611, showing an increase of 45,944 during the year. The number of locomotives per 100 miles of line was 20; the number of passenger cars per 100 miles of line was 17; and the number of freight cars per 100 miles of line was 714.

The increase in equipment has not proceeded as rapidly as the increase in train brakes and automatic couplers. The increase in equipment during the year, including locomotives and cars, was 47,943, while the increase in the equipment fitted with automatic couplers was 53,716, and the increase in equipment fitted with train-brakes was 39,505. The estimated increase in equipment for the year 1892 is 29,821, while the estimated increase in equipment fitted with automatic couplers is 98,563, and the equipment fitted with train-brakes is estimated to have increased 96,503. These figures show clearly that at the present rate it will be many years before the total equipment will be fitted with safety devices unless Congress sees fit to take prompt action in the premises.

MEN EMPLOYED.

The number of men employed on railroads in the United States during the year covered by the report was 784,285, being an increase of 34,984. The number of men employed per 100 miles of line was 486. The report brings an interesting fact to light by showing that the number of men in the employ of the railroads in proportion to the total population was 1 to 87 inhabitants in 1889; 1 to 84 inhabitants in 1890; and 1 to 82 inhabitants in 1891. From this it will be seen that the population of the country increases at a less rapid rate than that portion of the population engaged in transportation by rail.

The extent to which organized industry has increased the efficiency of labor is shown by the fact that every engineer, during the year, has on an average carried 369,077 passengers one mile and 2,329,639 tons of freight one mile.

CAPITALIZATION AND VALUATION.

The total capitalization of the railroads of the United States is $9,829,475,015, or $60,942 per mile of line. This shows an increase in outstanding capital of $602 per mile of line as compared with the 1890 report. An analysis of the changes in capital outstanding shows that income bonds have increased from $76,933,818 to $324,288,690. A considerable portion of this increase is probably due to a conversion of stocks into income bonds. It is significant because it shows an increase in that form of property for the management of which directors are not held to strict responsibility. Equipment trust obligations have also increased from $49,478,215 to $54,735,157. A few years ago the opinion prevailed that the leasing of equipment by railroad companies was fast disappearing. This opinion is not supported by the facts.

EARNINGS AND EXPENSES.

The gross earnings from operation during the year ending June 30, 1891, were $1,096,761,395, or $6,801 per mile of line. Operating expenses were $731,887,893, or $4,538 per mile of line, leaving the net earnings from operation $364,873,502, or $2,263 per mile of line. The net earnings per mile of line were less than the net earnings of the previous year by $37. An analysis of gross income shows that freight traffic gave rise to $736,793,699, or 67.17 per cent. of total earnings; and that passenger traffic gave rise to $281,178,599, or 25.64 per cent. of total earnings. The amount received from carrying mail was $24,870,015, and the amount received as rentals from express companies was $21,594,349. The analysis further shows that $133,911,126 were received as income from investments. The assignment of operating expenses shows that 34.08 per cent. is chargeable to the passenger service and 65.92 per cent. to freight service. The percentage of operating expenses to operating income was 66.73 per cent. The number of passengers carried during the year was 531,183,988; the number carried one mile was 12,844,243,881. The number of tons of freight carried was 675,608,323; the number carried one mile was 81,073,-784,121. The total number of miles run by passenger trains was 307,927,928, and the number of miles run by freight trains was 446,274,508. The average journey per passenger was 24.18 miles, and the average haul per ton of freight was 120 miles. The average number of passengers in a train was 42, and the average number of tons of freight in a train was 181.67. The average revenue per passenger per mile in 1891 was 2.142 cents, and the average revenue per ton per mile was 0.895 cent. The average revenue per train mile, passenger trains, was 106.111 cents, and the average revenue per train mile, freight trains, was 163.683 cents.

RAILROAD ACCIDENTS.

In narrating the statistics of accidents, the report shows that casualties during the year ending June 30, 1891, are greater than in any previous year covered by reports to the Commission. The number killed during the year was 7,029, and the number injured was 33,881. Of these totals, the number of employés killed was 2,660, and the number injured was 26,140. The number of passengers killed was 293, and the number injured was 2,972. A classification of casualties according to the kind of accident shows 415 employés were killed and 9,431 injured while coupling and uncoupling cars; 598 were killed and 3,191 injured falling from trains and engines; 78 were killed and 412 were injured from overhead obstructions; 303 were killed and 1,550 were injured in collisions; 206 were killed and 919 were injured from derailment of trains; 57 were killed and 319 were injured from other accidents to trains than collisions and derailments already mentioned; 20 were killed and 50 injured at highway crossings; 127 were killed and 1,427 were injured at stations; the balance, which makes up the total of 2,660 killed and 26,140 injured, is due to accidents which do not naturally fall in the classification adopted for report. Referring to passengers, 59 were killed and 623 injured by collisions; 49 were killed and 837 injured by derailments; 2 were killed and 34 injured by other train accidents; the balance, making up a total of 293 killed and 2,972 injured, being assignable to accidents at highway crossings and at stations and to other kinds of accidents.

This report emphasizes more strongly than previous reports the necessity of legislation compelling railroads to adopt train brakes and automatic couplers, and also suggests that some steps be taken besides the adoption of the train-brake to prevent the frequency of casualties from falling from trains and engines. The large number killed and injured from collisions also brings prominently into notice the necessity of some extensive use of the block system in the handling of trains and a more perfect application of the principle of personal responsibility in the case of accidents. An investigation into the matter of handling trains is recommended by the report. Not only are the accidents of the year covered by this report greater than those of previous years, but, when compared with the increase in employés, it is observed that they are relatively greater than those of the previous year. Thus, during the last year 1 employé was killed for every 296, and 1 employé injured for every 30 men in railroad service. The corresponding figures for the previous year are 1 man killed for every 306, and 1 man injured for every 33 employés. This same fact is also presented in another manner. The increase in the number of employés killed during the year covered by the report over the previous year is 9 per cent., and the increase in the number injured is 17 per cent., while the increase in the number of men taken into employment is less than 5 per cent. The corresponding comparison for casualties to passengers shows that, while there has been a relative decrease in the number of passengers killed, the number of passengers injured shows a much greater increase than the increase in the number of passengers carried. On the whole, the comparison of accidents for the two years leaves a very unsatisfactory impression, since it shows that liability to accidents

was greater during the year covered by this report than during the previous year.

RECOMMENDATIONS.

The report concludes with a recommendation for certain amendments to the Interstate Commerce Act, which, it is asserted, are necessary to render the statistics of the business of transportation complete and satisfactory. Thus, it is recommended that express companies and water carriers engaged in interstate traffic be required to make reports to the Interstate Commerce Commission similar to those now made by railroads, and that persons, companies or corporations owning rolling stock used in interstate traffic should be obliged to make annual reports so far as may be necessary for a complete statement of the kind of rolling stock used by railroads.

THE DRAINING OF THE ZUYDER ZEE.

(Note by J. de Koning, presented before the French Society of Engineers.)

For some time past, since the death of Chief Engineer Van der Toorn, the project for draining the Zuyder Zee has been in charge of Mr. Lely, who has finally completed the plans for the work, and who has reached some new conclusions. He admits that the building of a dike across the Zuyder Zee by way of the islands of Texel and Vlieland is not practicable, as the bottom is there composed of shifting sand. The plan originally proposed being thus laid aside, the substitute brought forward is the construction of a great dike from the shore of the province of Holland to that of Friesland by way of the island of Wieringen. The sea being shut out by this main dike, four subordinate dikes will then be built, each enclosing a section of land to be grained, and in the center will be left a lake, to be called Lake Yssel, which will receive the waters of the Yssel River, and will communicate with the sea by several locks.

The building of the main dike will assist very much in the construction of the subordinate ones, the height of which will be much less than would be required if they were exposed to the open sea. The lake will serve as an intermediate reservoir in which the waters of the various streams will be collected, and there will be no necessity for pumping.

The accompanying sketch map shows the general nature of the plan, the four areas of land to be drained being shown by the cross-lined sections.

The length of the main dike will be about 18½ miles. A coffer-dam will be built up to low-water mark, and behind this will be raised a bank of sand, covered and protected by a thick layer of clay, which will be well rammed down, and in its turn will be protected by riprap. The dike will be built up to a height of 16½ ft. above ordinary high tides; this will make its height from the bottom from 30 to 35 ft. It will be on an average 300 ft. thick at the base.

Great care will be necessary in constructing the final portion, when unusually high tides or storms may force a great mass of water from the sea into the Zuyder Zee through a comparatively small opening.

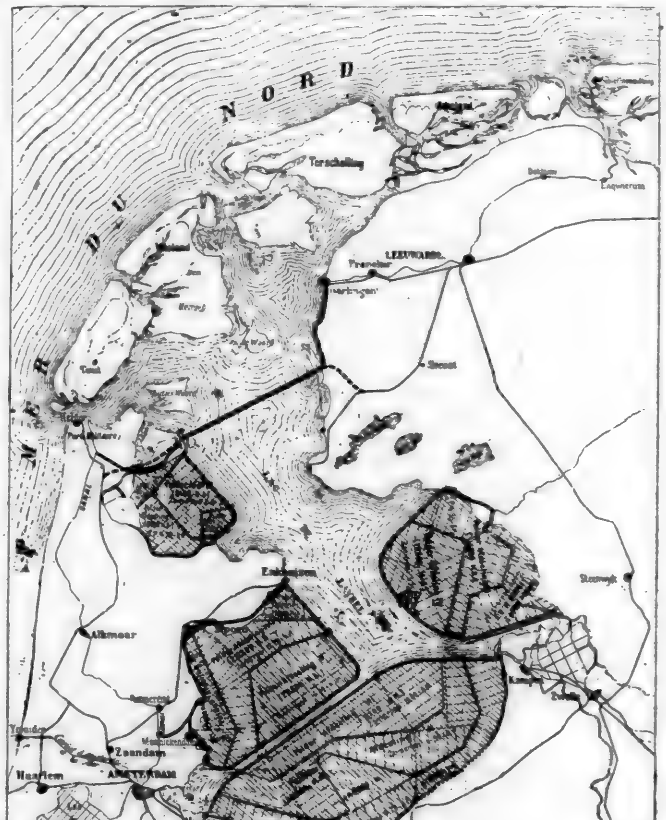
The building of the dike will take about eight years. This time cannot be much shortened, because of the great number of fascines and the quantity of stone which will have to be provided. Its estimated cost is about $17,000,000.

Even if the land drainage works should not be carried out, it is believed that this dike will be a useful work, for the following reasons:

1. The provinces behind the dike will be fully protected from inundation by the Zuyder Zee.
2. The cost of maintaining the present shore dikes will be greatly diminished.
3. The constant level of the water enclosed by the dike will secure a free and even flow of the streams discharging into it from the surrounding country.
4. The enclosed lake would be of fresh water, which could be used for irrigating the polders, or meadows, in dry seasons.
5. The dike itself would form a short and convenient road between two important sections of the country.

The dike, being provided with tide-locks of ample size, will give full facilities for navigation, and the fisheries will be the only interest which can be injured. It may be said, however, that the advantages presented above would be hardly sufficient to justify the expenditure, and the land drainage part of the plan must be considered.

The area behind the dike will be about 900,000 acres, of which 580,000 acres are to be drained. After making deductions for roads, canals, etc., there will be left about



THE ZUYDER ZEE.

540,000 acres of farming land. Careful examination and estimate shows that of this 71 per cent. will be excellent land, 19 per cent. moderately good, and only 10 per cent. poor.

The drainage of the land will be effected by building a dike around each section, and then pumping the water into Lake Yssel. As the work proceeds roads and canals will be built and the ground laid out into suitable lots.

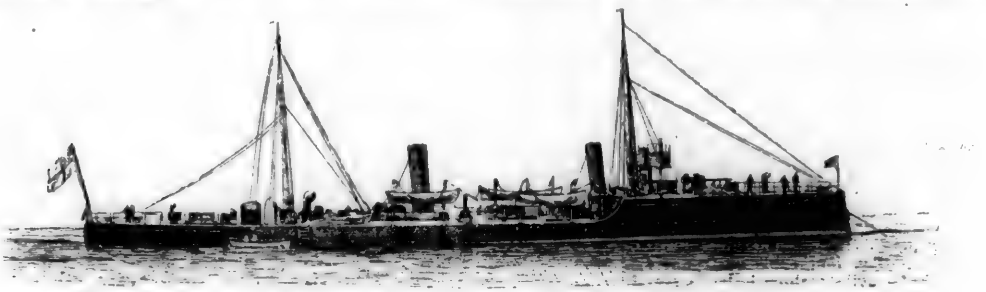
The cost of the drainage is estimated at $63,000,000. Adding to this $17,000,000 for the main dike, makes the total cost $80,000,000, or about $148 per acre to be reclaimed. Interest on capital during construction and other charges will raise the cost to about $160 per acre.

The first step will be the building of the main dike. When that is completed the work of draining the four areas to be reclaimed will be begun and gradually carried out. The entire work will require about 30 years for its completion. The drainage will proceed slowly in order to reduce to a minimum the danger from malarial fevers, which might arise from the exposure of too great a surface of new land. After 10 years the sale of land might commence, probably not more than 25,000 acres a year being put on the market at first. This quantity, it is believed, would be readily taken up without affecting the value of the remaining area. The total area of land will nearly double the extent of arable land in Holland.

The new plan meets many objections made to that first proposed. The extension of the work over a number of years is considered an advantage in many respects.

It may be mentioned that communication between Lake Yssel and Amsterdam will be established by a canal, which is shown on the map.

The plan outlined above has been submitted to a commission, whose duty it is to decide whether the Government will find it to its interest to undertake the work.



TORPEDO GUNBOAT "SPEEDWELL," FOR THE ENGLISH NAVY.

AN ENGLISH TORPEDO CRUISER.

The illustration given herewith is from *Le Yacht*, and shows the English torpedo-chaser *Speedwell*, a vessel of a type which is not as yet represented in our Navy. The construction of a ship of this class was authorized by Congress, but no contracts were ever let for its construction.

The *Speedwell* is one of thirteen, and is 230 ft. long, 28 ft. beam and 748 tons displacement. Her engines were intended to work up to 4,550 H.P. and to give her a speed of 21 knots an hour. She can carry 100 tons of coal.

The armament consists of two 4.7-in. rapid-fire guns, four 3-pdr. guns, a fixed torpedo-tube at the bow, and two torpedo-tubes amidships.

These boats were built to take the place of an earlier class the working of which was not satisfactory, since they proved very poor sea boats, though showing a high speed in smooth water. In their turn, however, the *Speedwell* and her sister boats have failed to come up to expectation, and some of them in the naval manœuvers of last year showed an amount of structural weakness which was not consistent with safety. The hulls proved too light for the engines, and even for a short time it was found unsafe to drive them over 17 knots an hour. One or two of them, after short runs at high speed, were found to leak to a dangerous extent.

A new lot of 11 of these torpedo-gunboats has recently been begun, but they will, while having the same length and beam, be given a little more depth and 810 tons displacement. The extra weight will be used to strengthen the hull. Moreover, the engines will be lighter—about 3,600 H.P.—and the speed will not exceed 19¼ knots. The engines of the present ships will probably be used for a larger class, having about 250 ft. length, 30 ft. beam and 1,100 tons displacement.

RIVETED JOINTS.

By H. deB. Parsons.

Although the strength of riveted joints has been discussed by many authors at considerable length, there still appears to be much misunderstanding in regard to them. Most of the experiments have been made on the thinner plates, while the present tendency is to use thicker plates of steel with drilled holes and power driven rivets. The proportions, as deduced from the earlier experiments, in consequence, do not hold true for these thicker plates, as the rivets would be of such large diameters as to be difficult and dangerous to rivet even with the most modern riveters. To-day the diameters of rivets suitable for the thicker plates are generally determined by practice and the size of the riveters in use rather than the rules laid down by theory.

Sir William Fairbairn deduced from experiments on ¼-in. and ⅜-in. plates that the proportion of strength of the whole plate to that of the joint was in the ratio of 100 to 70 and 100 to 56 for double and single riveting respectively. Comparing many of the later experiments, these proportions appear too high and further from the truth as the plates increase in thickness. Another error is caused by using a shearing strength for the rivet as equal to the tensile strength. One of our best-known boiler works uses this strength for shearing, but proportions its joints so that the shearing strength of the rivets shall exceed the strength of the plate between the rivet holes in the proportion of about 13 to 8 for iron rivets, and of 28 to 23 for steel rivets. Iron rivets are much more extensively used for boiler work at the present time, and, from a large number of tests examined, the shearing strength for them should not be taken to exceed 40,000 lbs. per shearing area in square inches for single shear, and 35,500 lbs. for double shear. There is no doubt that in certain cases the friction of the plates, caused by the grip of the rivets, assists the shearing strength; but as this does not always occur, it cannot be relied upon when proportioning so important a joint as that of a boiler.

Experiments on the strength of boiler plates between the holes show an increase of strength per square inch over that of the whole plate, as might have been expected, since the parts between the holes act like short specimens.

From experiments made by Professor A. B. W. Kennedy on steel plates,* this apparent increased strength amounts to about 11 per cent. of the strength of the plate when the holes are drilled. On account of the great difficulty in

* *Transactions*, Institute of Mechanical Engineers, 1881.

RIVETED JOINTS.

LAP OR BUTT WITH SINGLE WELT.—STEEL PLATES AND IRON RIVETS.

Thickness of Plates.	Diameter of Rivets.	Pitch.		Efficiency.	
		Single.	Double.	Single.	Double.
¼″	½″	1 3/16″	1⅞″	55.7 %	70.0 %
⅜″	⅝″	1 11/16″	2 11/16″	52.7 "	68.6 "
½″	¾″	1⅞″	2¼″	49.0 "	65.9 "
⅝″	⅞″	1 15/16″	2 7/16″	43.6 "	60.4 "
¾″	1 ″	1⅞″	2⅝″	42.0 "	59.5 "
⅞″	1 ″	1¾″	2 7/16″	38.6 "	55.4 "
1″	1⅛″	2 3/16″	2⅝″	38.1 "	54.9 "

properly matching the holes, and of the stress caused by forcing, as is too often the case in practice, this additional strength cannot be trusted much more than that of friction.

Adopting the sizes of iron rivets as generally used in American practice for steel plates from ¼ to 1 in. thick; the tensile strength of the plates as 60,000 lbs.; the shearing strength of the rivets as 40,000 for single shear and 35,500 for double shear, I have calculated the accompanying table of pitches, so that the strength of the rivets against shear-

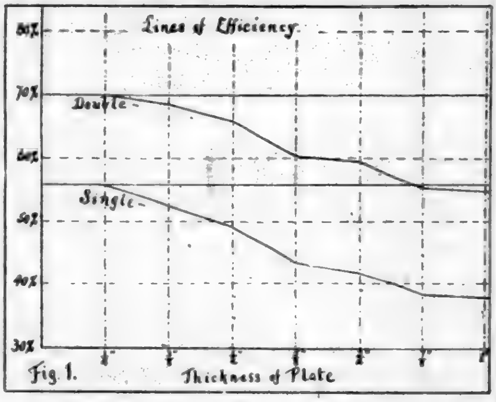


Fig. 1.

ing will be approximately equal to that of the plate to tear between rivet holes. The diameter of the rivets has in all cases been taken at 1/16 in. larger than the nominal size, as the rivet is assumed to fill the hole under the power riveter.

In fig. 1 I have laid out the lines of efficiency of the joints as calculated from the above data for both double and single riveting; the straight horizontal lines representing Fairbairn's relative strengths as a means of comparison.

Comparing the proportions of joints as used in many boiler shops, it will be seen that the joints are still less efficient than the above, and in many important boilers with ⅞ and 1-in. plates, the proportional strength is only 30 per cent., and less of that of the plates.

When the exact tensile strength is known, and still using 40,000 lbs. as the shearing strength, the calculated results compare very favorably with the actual results of experiment, usually not exceeding 5 per cent. difference. From tests made by the U. S. Board on "Iron and Steel," 1882, I find as an example for ½-in. steel plate, five ⅝-in. iron rivets at 2-in. pitch, the fracture took place by shearing, showing an actual efficiency of 48.2 per cent. against 53 per cent. calculated. With ⅜-in. plate, 11/16-in. rivets in punched holes, at 2-in. pitch, the rivets sheared, showing an actual efficiency of 45.4 per cent. against 45.6 per cent. calculated. The same is true for double-riveted joints; for instance, from the same report I find for ½-in. steel plate ⅝-in. rivets at 2-in. pitch, the plate fractured between the holes, showing 74.9 per cent. efficiency. The calculated efficiency was 70.8 per cent. if we add the 11 per cent. for apparent increased strength. And, again, for a ⅜-in. plate with 11/16-in. rivets in punched holes at 2-in. pitch, the plate fractured between holes, with 63.8 per cent. efficiency, having a calculated efficiency of 60.4 per cent. and 64.6 per cent. if we add the 7 per cent. increased strength as found by Fairbairn for punched plates.

Owing to the unevenness of the joint in practice, and the liability of damaging the plate between the holes by the use of the drift-pin—which even the most rigid specification does not seem to prevent—and by punching and insufficient reaming, the strength of the plate at the joint will decrease, but this decrease will be partially offset by the 11 per cent. additional strength above referred to. On the other hand, the shearing strength, as used plus the friction, is the maximum for the rivets, and as the holes never truly match for the whole length of the joint, the shearing area will be reduced accordingly; so that we may conclude that for boilers built with care the above proportions for plate and rivet strength will remain about equal. In practice it would be advisable to slightly increase the pitch, as given in the table, so as to allow for some of the holes to be reamed out in case they do not match, and also to allow for a reduction of the plate by wear, thereby sacrificing a little of the efficiency. But I see no reason why, with the size of rivets as used, the pitch should be as large as it is, which greatly diminishes the strength.

For the thicker plates the rivets should be larger to obtain a higher efficiency, but, owing to practical difficulties, larger rivets cannot be used successfully. There is, however, no good reason why the pitch should remain the same as if these larger rivets had been employed, and yet such is the common practice.

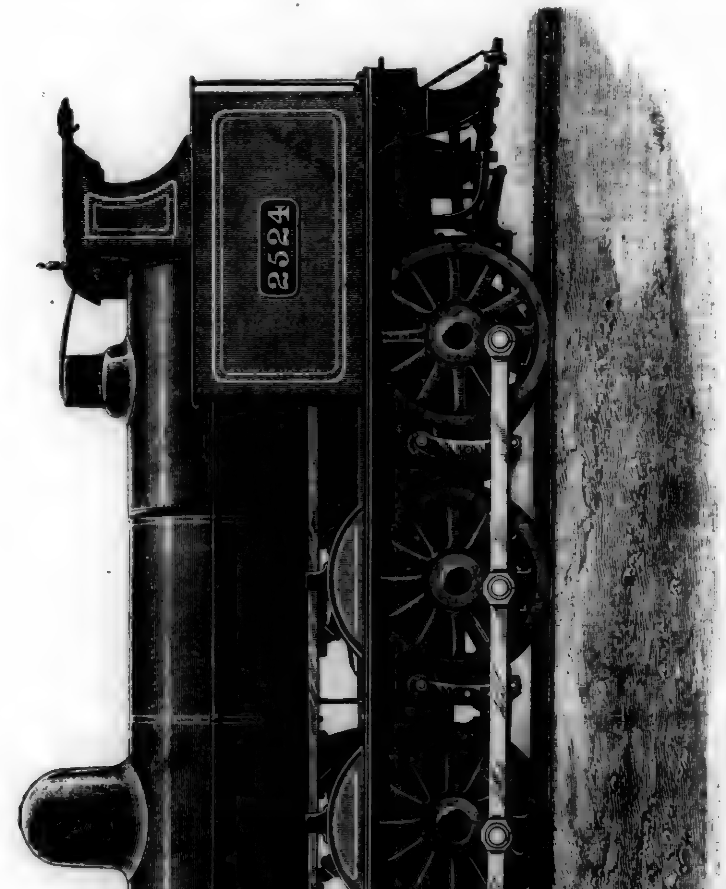
I have seen some boilers which the builders claimed had a factor of safety of six, but which really had only a factor of two. In such cases the extreme refinement of testing the sheets for tensile strength is valueless, and the time would have been much better spent in rearranging the proportions of the joint.

THE DELHI WATER WORKS.

(From the *Indian Engineer*.)

THE new water works at Delhi, which were designed and carried out by Mr. Parkes as Chief Engineer, were formally opened November 4.

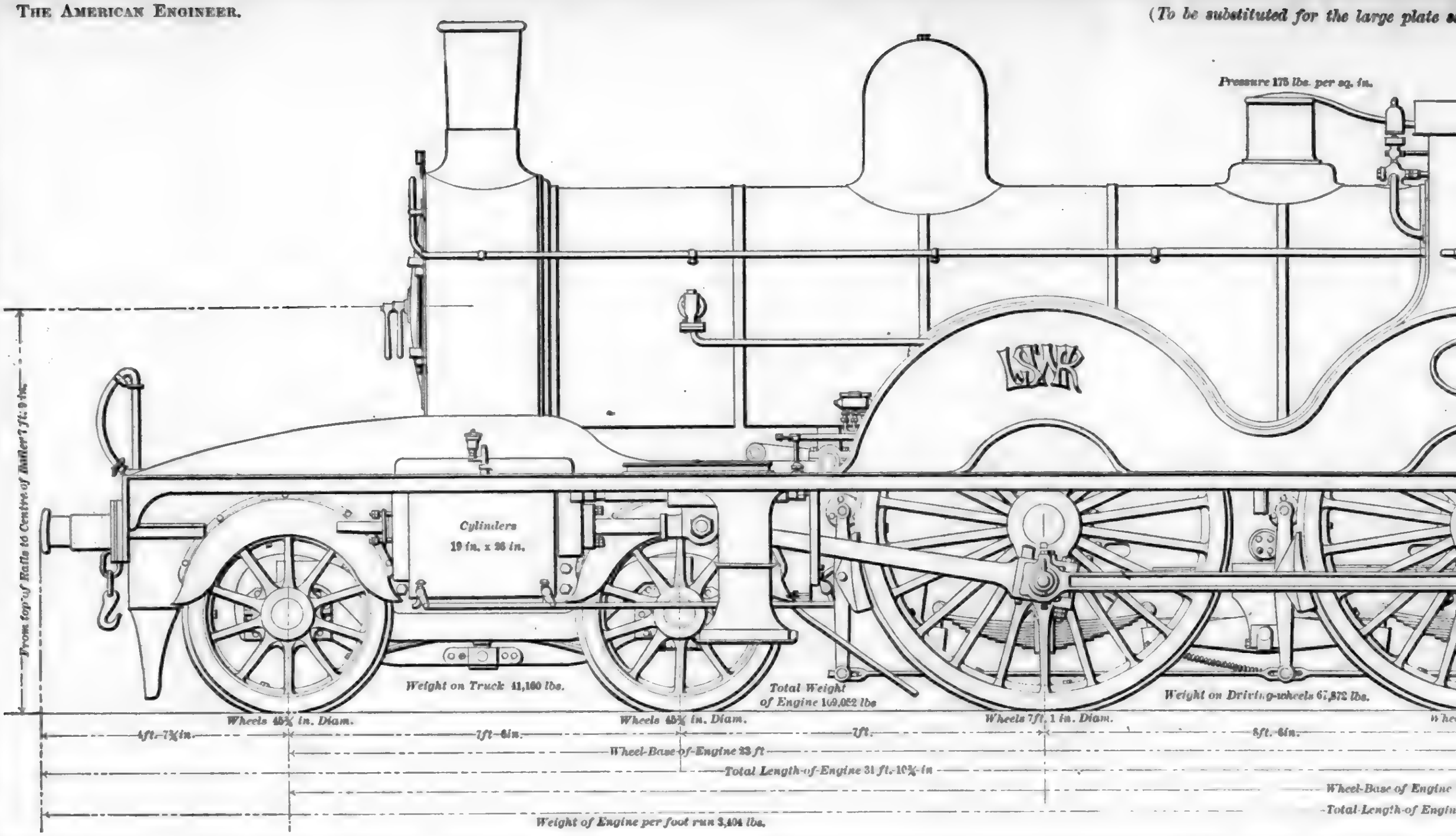
The works, which were begun in the early part of 1890, are calculated to supply an average of 10 galls. a day for a population of 173,000, equal to a total daily supply of 1,730,000 galls. It may here be mentioned that 10 galls. of water are about equal to a large-sized *mussuck*. The population to be supplied is included in the city, the fort and cantonments, and in the civil lines and suburbs. Of the total quantity about 70 per cent. will go to the city population. So far only half the estimated number of wells have been sunk. This was done in order to determine accurately the absolute number that would eventually be required for the complete supply; the method of obtaining filtered water from a river by a line of wells in close proximity to the running stream being unique in India. The number of wells constructed up to date is 43, the total daily supply obtained from them during the month of June last, when the water in the river was at its lowest level, hence at the most unfavorable season of the year, was 872,000 galls. in an ordinary day's pumping. This quantity is equal to about three-fourths of the full allowance for the city. With the completion of the wells the full supply for the city will be obtained, as well as that for the suburbs and cantonments. The water is led from the wells to the engine-house by a 3-ft. conduit, 500 ft. in length, consisting partly of brick masonry and partly of cast-iron pipes, imbedded in concrete. The majority of these pipes were successfully cast in Delhi at Bhana Mal and Gulzari Mal's foundry. The laying of the conduit under water necessitated continuous pumping, which delayed this part of the operations very considerably. The machinery used for pumping the water consists of two high-pressure Worthington triple-expansion jet-condensing engines, each of 100 H.P., and two multitubular Babcock & Wilcox boilers, together with two economizers for heating the feed-water to the boilers by means of the waste heat from the furnaces. Each engine, boiler and

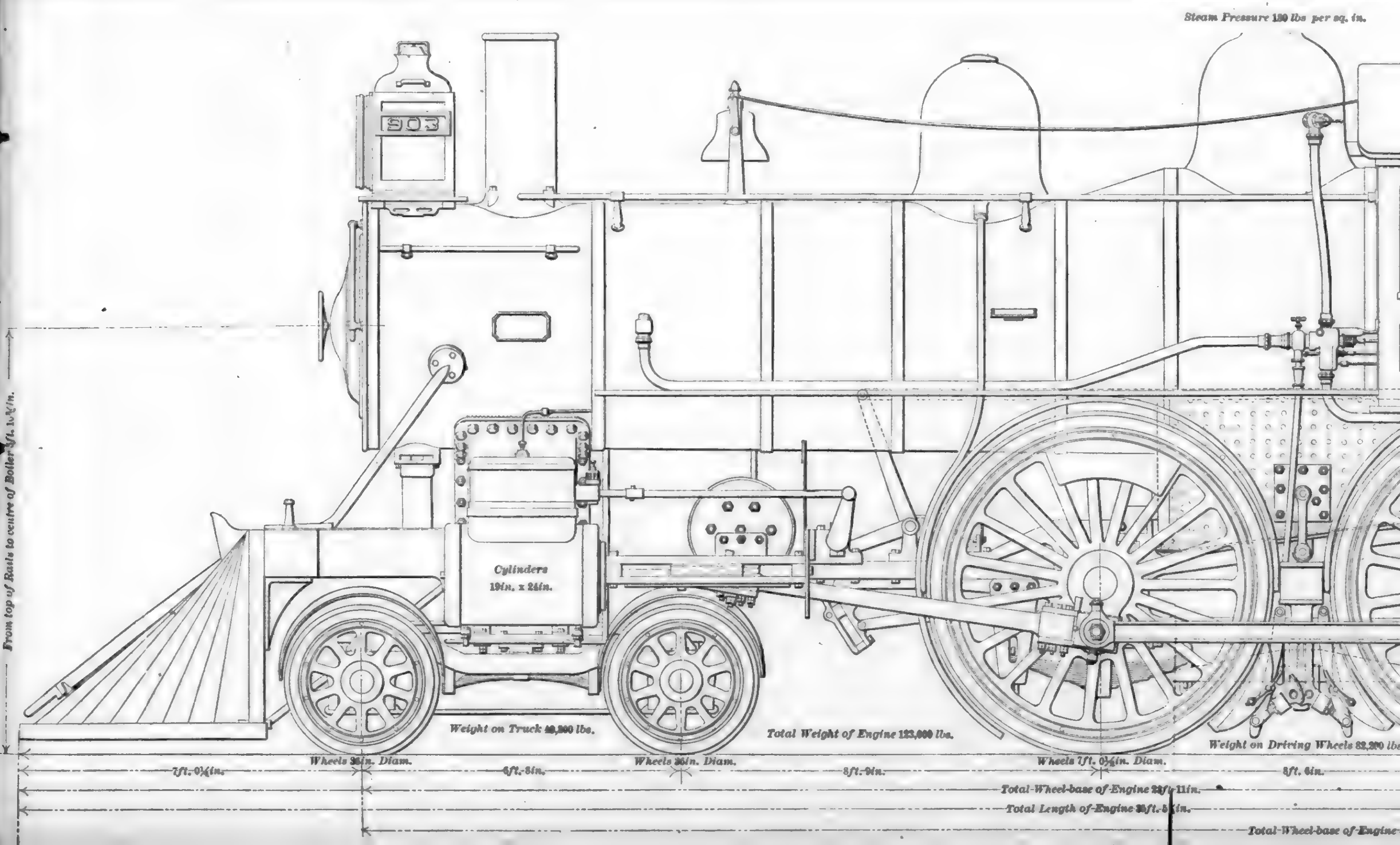


LOCOMOTIVE FOR COAL TRAFFIC, LONDON & NORTHWESTERN RAILWAY.

DESIGNED BY F. W. WEBB, LOCOMOTIVE SUPERINTENDENT; BUILT AT COMPANY'S SHOPS, CREWE, ENGLAND.

(*To be substituted for the large plate s*

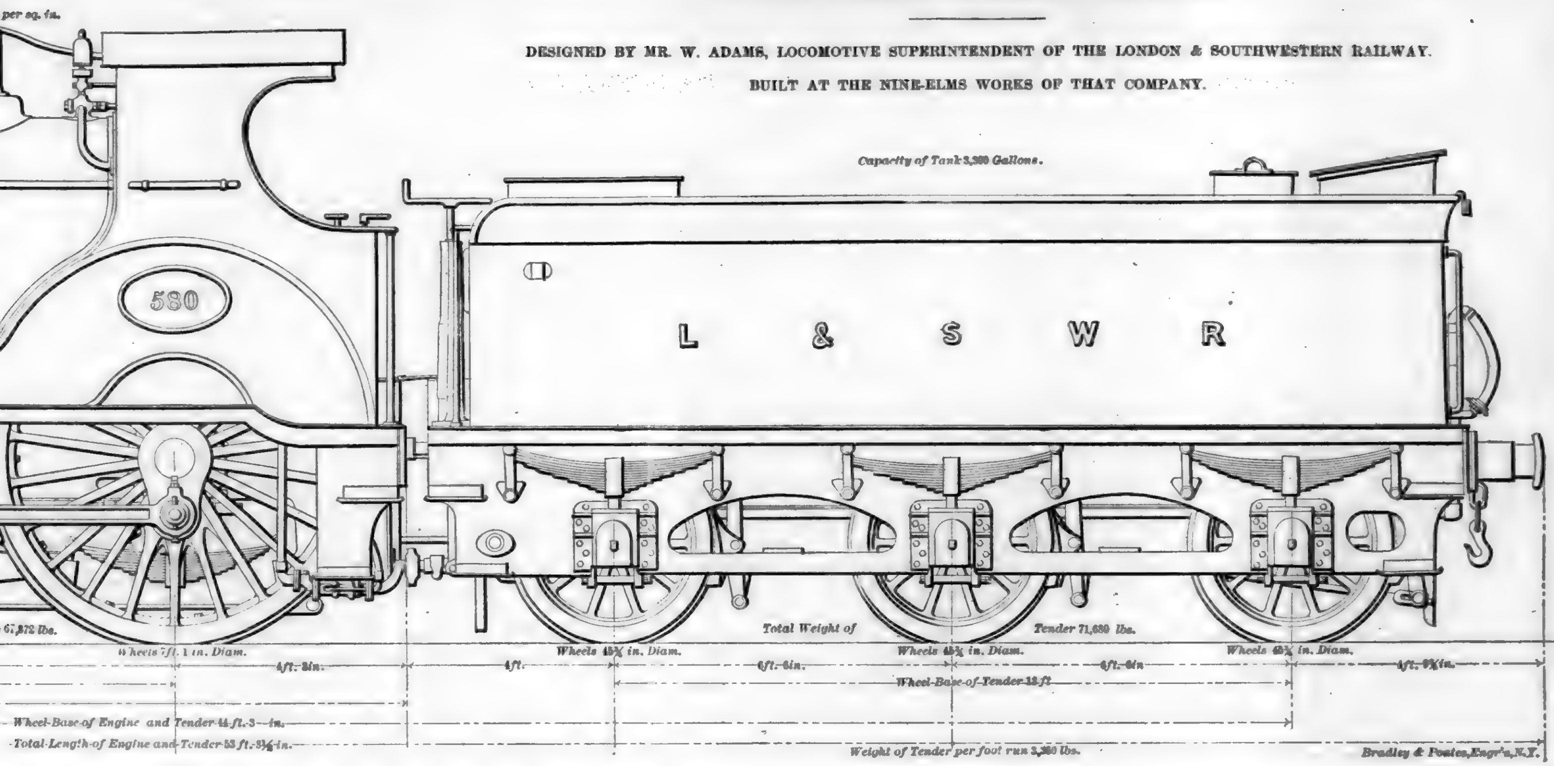




ENGLISH EXPRESS PASSENGER LOCOMOTIVE

DESIGNED BY MR. W. ADAMS, LOCOMOTIVE SUPERINTENDENT OF THE LONDON & SOUTHWESTERN RAILWAY.

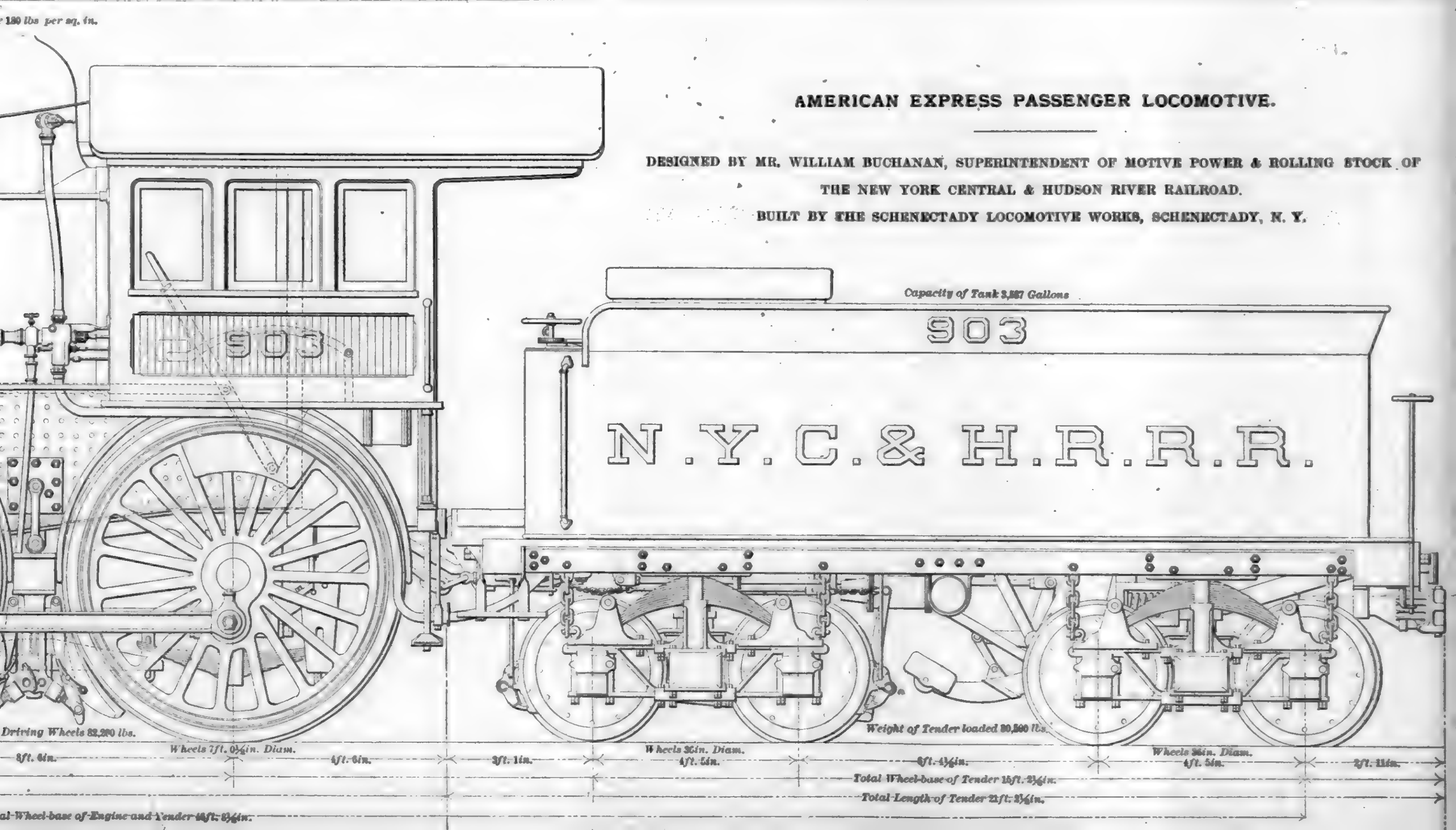
BUILT AT THE NINE-ELMS WORKS OF THAT COMPANY.



AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

DESIGNED BY MR. WILLIAM BUCHANAN, SUPERINTENDENT OF MOTIVE POWER & ROLLING STOCK OF THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

BUILT BY THE SCHENECTADY LOCOMOTIVE WORKS, SCHENECTADY, N. Y.



economizer is capable of raising, separately and independently, 1,750,000 galls. of water in 16 hours from the well underneath the engine-house, and forcing it through 6,000 ft. of rising main 18 in. diameter to the reservoir, the total vertical height being 140 ft.

The reservoir is built on the highest point of the ridge, immediately to the east of Hindu Rao's house. The top water level in the reservoir is 90 ft. above the average level of the city. The dimensions of the reservoir are 300 ft. in length and 150 ft. in breadth, and when full it will have a depth of 10 ft. of water. The cubical capacity is over 2,500,000 galls., equal to $1\frac{1}{4}$ days' supply for the whole population. The inside of the reservoir has been plastered with a thin coat of Portland cement, in order the more effectively to scour and clean it out on occasions when this has to be done. The walls of the reservoir are constructed of stone masonry, and the roof consists of concrete arches, the whole being covered in with earth to keep the water cool. The water can, at any time, when required, be pumped direct into the city main through a by-pipe, without passing through the reservoir.

From the reservoir to the city the water flows through a main about 8,000 ft. long. This main has a diameter of 24 in. as far as the canal crossing. In order to permit of the extension of the system to the suburbs of Delhi, three branch pipes take off in this length, one for the Sabzimandi, the second for the civil lines, and a third to supply the suburbs of the Sadar Bazaar and Paharganj. From the canal crossing to the Lahore Gate of the city the main is reduced in size to 21 in. diameter. Within the city the total aggregate length of piping is 111,500 ft., rather more than 21 miles, varying in diameter from 18 in. to 3 in. This piping supplies all the intramural population, exclusive of the fort, the cantonment at Dariaganj, and the railroad station. Hydrants have been erected along every line of main piping, at intervals of 200 to 400 ft., according to the density of the population. To facilitate the extension of the pipe system, and to permit of the eventual introduction of house-connections in every street and *guli*, extra branch pipes have been provided, where necessary, on all the mains. The total estimated cost of the works is about $500,000, of which $440,000 have been expended up to date.

THE LATEST ENGLISH FREIGHT LOCOMOTIVE.

THE illustration given herewith, from the London *Engineer*, shows a new type of freight locomotive designed by Mr. F. W. Webb, Locomotive Superintendent of the London & Northwestern Railway, for working the heavy coal traffic on that road.

The boiler is of the pattern devised by Mr. Webb and used by him in his latest compound engine, the *Greater Britain*.* The tubes are divided into two lengths by a

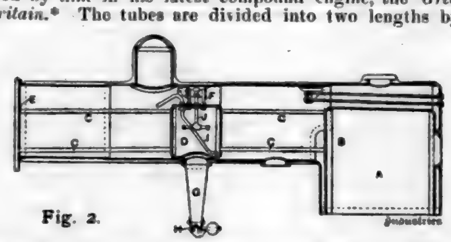


Fig. 2.

combustion chamber; the back group, extending from the fire-box to this combustion chamber, being 4 ft. 10 in. long, and the front group, from the combustion chamber to the smoke-box, being 8 ft. 1 in. long. This makes an unusually long boiler. The barrel is 51 in. in diameter and 15 ft. 6 in. long; the outside fire-box is 6 ft. 10 in., making the total length of boiler 22 ft. 4 in. There are 156 tubes $2\frac{1}{4}$ in. in diameter, the lengths being given above. The grate area is 20.5 sq. ft.; the heating surface is: Fire-box, 114.7; combustion chamber, 39.1; back tubes, 408.5; front tubes, 683.0; total, 1,245.3 sq. ft. The boiler is built for 160 lbs. working pressure. Fig. 2, which is from Mr. Webb's patent specifications, shows the general design of the boiler.

The cylinders are inside and are $19\frac{1}{2}$ in. in diameter and 24 in. stroke. The steam-chests are above the cylinders, and the valves are worked by Joy's gear.

The wheels, which are all coupled, are $53\frac{1}{2}$ in. in diameter. The leading and trailing wheels have $\frac{1}{8}$ in. side play in the axle-boxes. The axles are at equal distances, 5 ft. 9 in., making the total wheel-base 17 ft. 3 in. The springs on the first three pairs of wheels are equalized; the trailing wheels have an ordinary cross spring. Each coupling rod is complete in itself, and they are arranged so as to be interchangeable.

The total weight of this engine in working order is 104,900 lbs., which is distributed as follows: Leading wheels, 26,100 lbs.; main driving-wheels, 28,400 lbs.; third pair, 26,100 lbs.; trailing-wheels, 24,300 lbs. The weight of the tender in working order is 56,000 lbs.

The crank-axle bearings are 9 in. long, and there is a central frame carrying a $5\frac{1}{2}$-in. bearing on the driving axle which is intended to assist in taking up the stress due to the connecting rods. The crank-axle bearings have thus a total length of $23\frac{1}{2}$ in.

This engine is of unusual size, the great majority of English freight engines having six coupled wheels. In fact, the *Engineer* says: "This is, we believe, the first eight-coupled locomotive engine having a tubular boiler made in this country."

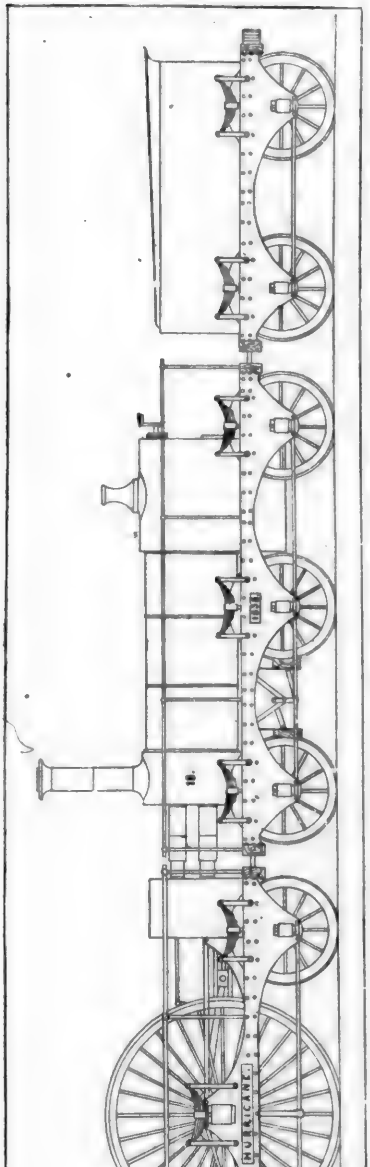
It may be added that the Webb boiler in the *Greater Britain* has now been in regular use over a year with very satisfactory results.

* See the RAILROAD AND ENGINEERING JOURNAL for January, 1891, page 18; and for April, 1892, page 156.

THE MANUFACTURE OF RIFLES.

WE give below an abstract of a paper read recently before the English Institution of Civil Engineers by Mr. John Rigby, Superintendent of the Enfield Rifle Factory, describing the manufacture of the Lee-Metford magazine rifle of 0.303 in. caliber, the weapon adopted for the British Army:

The most important part of a rifle was the barrel, which had always engaged the special attention of gun-makers. Up to the time of the Crimean War, it was, for the bulk of British troops, a comparatively rude tube of iron, lap-welded under rolls and tapering externally, with a cylindrical bore of about $\frac{5}{8}$ in. diameter. The barrel of the present day was a steel tube of accurate workmanship, only 0.3 in. bore, almost perfectly true and straight, rifled to $\frac{1}{2000}$ in., and so closely inspected that the existence of the most minute crack or seam in the bore, requiring a highly practised eye to detect it, was sufficient to condemn it. The material used was produced either by the Siemens-Martin or the crucible process of manufacture, and was supplied to Enfield as a solid round bar $1\frac{3}{8}$ in. diameter and $15\frac{1}{2}$ in. long. After severe testing, this bar was passed through a rolling-mill to draw it to its full length; it was then taken to the forge, the swell at the breech-end was stamped to the required shape by a steam-hammer, and afterward straightened cold. The next step was to submit the bar, without annealing, to the turning and drilling-machines. The latter were horizontal, the drills operating from each end. In the process of drilling, the barrel revolved at nearly 1,000 revolutions a minute against half-round bits held flat down, a capillary tube, of brass, supplying a soap-and-oil emulsion, at a pressure of 80 lbs. to the square inch, to wash out the swarth and cool the cutting-edge. The drills advancing from each end continued boring until a small disk about 0.01 in. diameter broke out, and the two holes met. The tendency of the drills to follow the line of axis of a revolving bar was one of those curious occurrences in practical mechanics which might be accounted for after observation, but which no one would predict. Occasionally, through some defect in the steel, a drill wandered from the axial line; in this case the barrel was taken from the machine and reset sufficiently to bring the hole true again. To test its truth, a ray of light was made to illuminate the flat bottom of the hole while the barrel slowly revolved. It was very rarely that a barrel was rendered waste from bad drilling. Rough boring followed with a three-edged bit, the blade being about 4 in. long. The rough external turning was effected in self-act-



LOCOMOTIVE "HURRICANE," WITH 10-FT. DRIVING WHEELS; GREAT WESTERN RAILWAY, OF ENGLAND.

BUILT BY HAWTHORNE & COMPANY IN 1838, FROM DESIGNS OF T. E. HARRISON.

ing lathes, which gave the required curved taper. Three or four cutters acted simultaneously, each producing a long cutting that attested the quality of the metal of the barrel. The operation of barrel-setting followed. Previous to rough-turning, the barrels were fairly straight internally, but the removal of the metal caused slight inequalities which were tested by the eye of the barrel-setter, and corrected by transverse blows. This constituted skilled labor of a peculiar character, and was performed by young men of good sight, who were specially trained for the purpose. After middle life the eye generally lost some of the quality necessary for this work, and it was rare to find a man excel in it after that period. Many mechanical devices had been contrived to supersede the simple ray of light laid, as if it were a straight edge, along the surface of the bore; but the eye still remained the arbiter of straightness, and could be relied on for very accurate results. The construction of the barrel was completed by the important operation of rifling. In British small-arm factories the system was followed of planing out each groove separately with a hooked cutter, and had been brought almost to perfection. In Continental and American factories the grooves were ploughed out by cutters, with several cutting or knife-edges set at an angle and following one another in the manner of a single-cut file or float. Similar machines had been tried at Enfield, but did not give as smooth a cut as the slower-moving, single-tooth machines. A few passes of a lead lap, fed with fine emery, removed any burr that might remain, and completed the polish; a cylindrical lap, spinning rapidly, was then passed through, and gave the final finish to the barrels. The limits of gauging were from 0.303 to 0.305 in.

Next in importance to the barrel was the mechanism of the breech, for which the material preferred was crucible cast steel of a mild character, but capable of being hardened in those parts exposed to the pressure of the bolt. The body was forged in two operations under the steam-hammer; it was then drilled and subjected to a long series of operations, in the course of which the end was recessed to receive the screwed end of the barrel, and the corresponding thread in the recess was milled out in a specially contrived machine, which insured that the thread should always start in the same place relative to the gauged part of the body, a point of great importance. The bolt, also of crucible cast-steel, was forged under the steam-hammer. A special machine, invented at Enfield, was used to finish the bolt after shaping. After machining, the bolts, packed in wood charcoal in iron cases, were heated and hardened by immersion in oil. The temper of the handle was then reduced in a lead bath. The rest of the bolt was tempered straw-color. The bolt-head was similarly hardened and tempered.

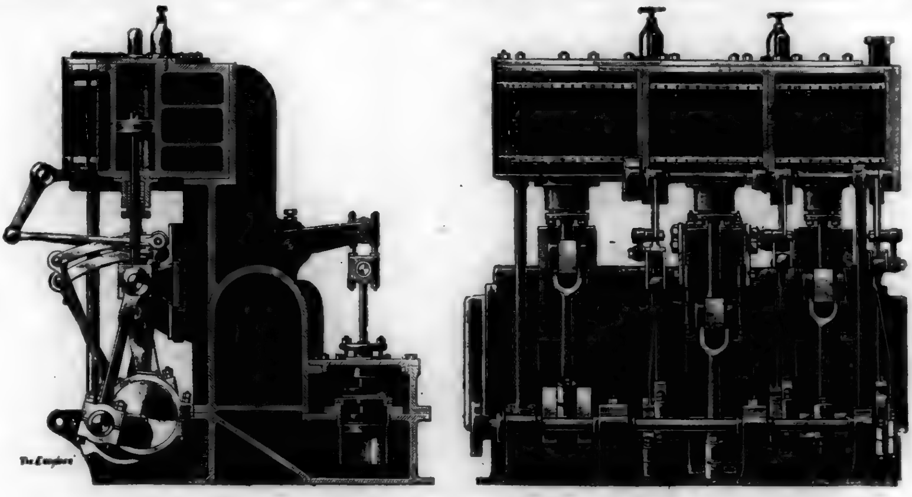
The other components of a complete rifle were mostly shaped by mills built up to the proposed profile, or by copy-milling machines. The process of drifting was used with good results at Enfield. All such slots or perforations as had parallel sides, and were not cylindrical, were so finished. The common practice in drifting was to push the drift, but at Enfield much better work was accomplished by pulling. It was found that used in this way drifts were very valuable for interchangeable work. The sides were cut with successive teeth, each slightly larger than the preceding one, and the whole length of the drift was drawn through. Emery wheels were also largely used at Enfield as a substitute for finish-milling and filing. The wheels ran under hoods connected with a pneumatic exhaust that carried away the heated particles of steel and grit. It was popularly supposed that a machine once adjusted to turn out a component of a certain size and shape was capable of reproducing such in large numbers, all absolutely identical. This was so far from being the case that no die, no drill, and no milling-cutter actually made two consecutive articles the same size. The wear of the cutters or dies proceeded slowly but surely, and it was only possible to produce in large numbers components of dimensions varying between a superior and an inferior limit. In small-arm manufacture a variation of about one two-thousandth of an inch was about the amount tolerated, but it varied according to the size of the piece. A difference of diameter of one two-thousandth of an inch in the sight axis-hole, and in the size of the pin or axis, would cause a serious misfit, whereas a similar difference in the measurement of the magazine, or

of the recess in which it lay, would be quite immaterial. The operations of gauging, proving the barrel, and sighting, were successively described, as also the manufacture of the stock, which was of the wood known as Italian walnut, though largely grown in other countries. Among the smaller components, the screws were mentioned as being rapidly produced by the automatic screw-making machines of the Pratt & Whitney Company.

The Component Store received the various finished parts, which numbered 1,591, or, including accessories, 1,868, and issued them to the foreman of the assembling-shop. Theoretically, the assemblers should have nothing to do but to fit and screw them together, but in practice small adjustments were found necessary. The amount of correction was generally exceedingly small, and was done wherever possible with the aid of emery wheels. The completed arms were submitted to inspection, and then issued in cases of 20 each to the Weedon Government Store or elsewhere.

THE FIRST TRIPLE-EXPANSION MARINE ENGINE.

The London *Engineer* says: "Who invented the modern triple-expansion marine engine? We cannot answer the question with certainty; but until evidence of earlier invention is produced, we think that Messrs Russell, Spence & Company, of Glasgow, may claim the honor. The engine which we illustrate herewith is to all intents and purposes the same as the modern marine engine, and it was designed before the *Propontis* and *Aberdeen* were heard of."



THE FIRST TRIPLE-EXPANSION MARINE ENGINE.

We reproduce the illustration here. The *Engineer* does not give the date of the design, nor does it say when the engine was built. If it was really the first triple-expansion, it is of interest from that fact alone, and also as showing that in later designs there has not been very much variation from the original type, as the *Engineer* intimates.

THE LOCOMOTIVE WITH THE LARGEST DRIVING-WHEELS.

The drawing given herewith, which is from a blue print forwarded to us by Mr. Clement E. Stretton, of Leicester, England, shows a locomotive which, it is believed, had the largest driving-wheels ever used on a railroad.

This locomotive, named the *Hurricane*, was built by Hawthorne & Company, in Manchester, England, for the Great Western Railway, from designs made by Mr. T. E. Harrison, an engineer then in the service of the road. It was built in 1838, and was altered at a date not precisely known, but supposed to be about a year later, into the form shown in the drawing.

The design was a very peculiar one. The engine consisted of three separate cars or carriages coupled closely together. The first carried the cylinders and machinery, and was supported by six wheels. The center pair were the drivers, 10 ft. in diameter; the leading and trailing pair were 54 in. in diameter. The driving-axle passed above the bed or floor of the carriage, and the cylinders were coupled by connecting rods to the cranks in the axle. The two cylinders were 16 in. in diameter and 20 in. stroke, and were placed on the rear end of the carriage. It would seem that this carriage must have been loaded in some way, as the weight of the car itself and the machinery would hardly have given adhesion enough to the drivers, especially as they could not have carried much over one-third of the weight of the car. Of what load was used or how the necessary adhesion was secured we have no account.

The second carriage in the series consisted of a simple frame supported on six 54-in. wheels and carrying the boiler, which was about 48 in. in diameter. The outside fire-box was 60 in. long. The steam-pipes passed through the smoke-box and then to the cylinders on the forward car, the connection apparently being made by a sliding joint, and the exhaust pipe was returned to the smoke-box in the same way. The road was 7 ft. gauge, so that there was no difficulty in securing as wide a fire-box as might be desired. The heating surface was 624 sq. ft.

The third car was the tender. It was on four 54-in. wheels and carried the tank and coal-box.

In Wood's *Treatise on Railroads*, published in 1838, the *Hurricane*—then described as being under construction in Hawthorne & Company's shops—is referred to, and a somewhat imperfect drawing is given. From this it appears that as originally built this engine had drivers 5 ft. in diameter. The cylinders were coupled to an independent crank-shaft carrying a large pinion which geared into another on the driving-axle. The gearing was so proportioned that the driving-axle made two revolutions to one of the crank-shaft. The object was to attain a high speed without using too great a piston speed. The object of placing the cylinders and drivers on a separate carriage was to give more room and have the machinery open to inspection.

Great things were expected of this engine, which was to run express trains at the rate of 40 miles an hour. It is evident that the gearing did not work well, for in a short time it was taken out and the *Hurricane* was changed to the form shown in the drawing, with 10-ft. driving-wheels.

Of her performance in the later form we have no record, but it does not appear that any more of the same type were built; so the natural conclusion is that the results obtained

were not favorable. Insufficient adhesion, too much complication and difficulty in keeping the steam-pipes tight will all suggest themselves as reasons for dropping this type of engine, which was only one of the many experiments in locomotive design tried on the Great Western Railway under Mr. Brunel.

AERIAL NAVIGATION AT THE COLUMBIAN EXPOSITION.

THE Committee on Aerial Navigation of the World's Congress Auxiliary has issued a circular in relation to the meeting to be held as a division of the Department of Engineering during the continuance of the Exposition at Chicago. The Committee is composed of Mr. O. Chanute, Chairman; Professor A. F. Zahm, Secretary; Messrs. Elisha Gray, LL.D., H. S. Carhart, S. W. Stratton, Ira O. Baker, John Guerin, B. E. Sunny, E. L. Corthell, R. W. Hunt, D. J. Whittemore, J. W. Cloud, B. J. Arnold and W. N. Rumely. The circular is given in full below:

In connection with the various Congresses which will be held next year, under the auspices of the World's Congress Auxiliary, it is proposed to hold in Chicago, in 1893, an International Conference on Aerial Navigation, somewhat similar to that which took place in Paris during the French Exposition of 1889; the subject being one which, while it has hitherto been left chiefly in the hands of the more imaginative inventors (perhaps in consequence of the prodigious mechanical difficulties which it involves), has of later years attracted the attention of some scientific men and engineers.

Objects.—The principal objects of the conference will be to bring about the discussion of some of the scientific problems involved; to collate the results of the latest researches; to procure an interchange of ideas, and to promote concert of action among the students of this inchoate subject.

It is proposed to invite the attendance of delegates from the various aeronautical societies of the world, and generally of persons who are interested in the scientific discussion of the subject.

Time and Place.—The Auxiliary Management has assigned the afternoons of three days for this conference, being Tuesday, Wednesday and Thursday, August 1, 2 and 3, 1893. The opening session will take place at 2.30 P.M., on Tuesday, August 1, in one of the halls of the World's Congress Art Palace, now being built on the Lake Front Park, at the foot of Adams Street, in Chicago. The sessions upon the two subsequent days will also take place in the afternoon, and may either, like the first, be joint sessions, or the members in attendance may divide into two sections (A and B) as may be decided hereafter.

Topics Selected.—The topics selected for papers and discussions are as follows:

I.—SCIENTIFIC PRINCIPLES.—JOINT SESSION.

1. Resistance and supporting power of air, including results of recent experiments; formulas for the resistance of balloons or flying machines, etc.
2. Best forms of aerial propellers, including results of experiments with screws, wings, or other forms; their efficiency and the power required.
3. Motors for aeronautical purposes, whether steam, gaseous, electric, explosive, etc.; their effectiveness, safety and weight per horse power.
4. Materials for aeronautical construction, whether for balloons or flying machines; including the strength and weight of fabrics, metals, woods, etc.
5. Best structural forms for aeronautical constructions, so as to combine strength and lightness; to offer the least resistance to progression, and to alight safely.
6. Behavior of air currents, including observations at various altitudes; the prevalence, the direction, the trend and the force of winds, etc.

II.—AVIATION.—SECTION A.

1. Observations and experiments on the flight of birds, including their methods of rising, gliding, alighting, etc.; measurements of power exerted and of velocities.
2. Theories regarding the soaring and sailing of birds. It is now generally admitted that birds utilize the wind in soaring, but no satisfactory explanation of the performance has been given.
3. Various types of proposed flying machines, their advantages and defects, the power required, their safety; differences between natural and artificial wings, etc.
4. Equilibrium of flying machines, including the best means of securing safety, with wings, screws, aeroplanes, etc., in rising, sailing and alighting.
5. Novel experiments in aviation and their results, either with power machines, dirigible parachutes, gliding or soaring devices, models, etc., etc.
6. Experiments with kites; results of different forms as to stability, sustaining power, height attained, behavior, etc. A history of kites.

III.—BALLOONING.—SECTION B.

1. Construction of balloons, choice of fabrics, laying out, cutting and sewing, varnishes, nets, cars, valves, anchors, guide ropes, parachutes, etc.
2. Inflation of balloons; hydrogen, coal gas, natural gas, hot air, etc.; their generation, cost, and management during inflation.
3. Navigable and war balloons, past experiments and results; the present status; the resistance, propellers, motors, speeds, etc., etc.
4. Manœuvring of balloons, ascending and descending, with least expenditure of ballast or gas; utilizing wind currents, determining altitudes, etc.
5. Observations in balloons, meteorological, photographic, topographical, military, naval, planimetric, etc., various instruments required.
6. Proposed improvements in balloons, as to forms of minimum resistance, increased strength and stiffness; with calculations of power required and lifted.

The Organizing Committee may arrange upon application for the introduction and discussion of topics not enumerated in the above list.

Proceedings.—It is intended to introduce each of these topics by the reading of one or more papers thereon, to serve as a basis for discussion, and to draw out further information. These introductory papers will be obtained both by solicitation of the Organizing Committee and by voluntary contribution. They need not be long nor very exhaustive, but decided preference will be given to those stating the results of actual experiments, as facts and positive knowledge are deemed more instructive than theories or projects. It is expected that some of these papers will be printed and distributed in advance, in which case it will be preferred to receive discussions thereon in writing.

No paper will be read unless it has previously been approved by the Committee of Organization. The management of the World's Congress Auxiliary will appoint the officers to preside over the various sessions, and these officers will arrange the order of the proceedings, call up in their turn the various papers, and the speakers whom the Organizing Committee may have selected to discuss them. Papers previously printed will generally be presented by abstract, so that discussion may follow without loss of time. Persons desiring to join in the discussions will be expected to give previous notice, and the remarks of speakers will generally be confined to fifteen minutes, and to not more than two speeches upon the same subject. It is preferred that speakers shall subsequently furnish a résumé of their remarks in writing, failing which the stenographer's notes will be edited by the committee.

Stenographers will be in attendance, and interpreters will be provided when previous notice has been given of remarks to be made in other than the English language.

It is expected that a separate room will be provided, in which to exhibit, on approval of the committee, small models or interesting experiments during the intermissions between the meetings. Should circumstances warrant, one or two additional sessions may be held.

Cards of Admission.—Personal cards of admission to the Conference will be issued in advance by the Secretary of the Organizing Committee upon application to him, approval by the committee, and the payment of a contribution of $3 to the publication fund. These cards will entitle the

holder to attend the Conference and to receive all of its subsequent publications.

Publications.—The Committee of Organization will decide how much of the papers and proceedings shall be printed, and will cause the same to be edited. Such of the papers as may be printed in advance will be mailed to the holders of cards of admission who may request it, and designate the particular topic or topics which they desire to discuss. Written discussions thereon should be forwarded to the Secretary in advance of the Conference, and after its close all such papers and discussions as may be printed shall be mailed to the members thereof.

Organization.—The President of the World's Congress Auxiliary has appointed a local committee to organize the affairs of the proposed Conference. It is to be assisted by an Advisory Council consisting of the leading scientific authorities on the subject throughout the world. Persons desiring to secure cards of admission or to contribute to the papers or discussions are requested to advise the Secretary at an early day, stating in the latter case what is the class of researches or experiments which they have made, and on what topics they desire to receive advance papers.

All communications should be addressed to Professor A. F. Zahm, Secretary, Nôtre Dame, Indiana.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 41.*)

But these wonderful performances of the "sailing birds" are chiefly witnessed in tropical or semi-tropical regions—those in which the steady trade winds or the regularly incoming sea breezes afford daily to the birds the power of performing their evolutions in search of food. In the more temperate regions the wind does not blow every day with just the right intensity, the casual soaring bird is frequently compelled to resort to flapping, and the would-be inventor has his thoughts directed to some form of a power machine; generally some combination of aeroplanes with propelling screws, which differs a good deal from the simple, compact, and severe outlines indicated by nature.

The form of the soaring bird is reducible to three elements. First, a comparatively large body, shapely, but unsymmetrical fore and aft, presumably the solid of least resistance to the air; second, a symmetrical pair of wings, convex on top, and more or less concave beneath, with a sinuous and stiff front edge; and, third, a tail, which varies greatly in its proportion among the various species. For these features, most of the inventors have substituted a small, boat-like body, a combination of flat planes, and flat rudders, both horizontal and vertical, which last is not found to exist in the bird.

A good case in point is found in the instance of Mr. *Krueger*, who patented in the United States, in 1882, a flying machine consisting in three flat horizontal planes set one behind the other, the front one being triangular in plan, while the rear one might be shaped like the tail of the swallow. These were to be adjustable, so as to guide the machine up or down. Beneath them was to hang a ship or vessel, and above them were to be set still other planes, sloping like the two sides of a roof, in order to act as a parachute. Four propelling screws were to be arranged between the three sustaining planes, while four adjustable keel cloths, vertically affixed both above and below the sustaining planes, were to steady the course and to furnish the steering power.

No particular motive power was proposed, and no method indicated for maintaining the stability, so that it is quite safe to say that no experiments were ever tried with this apparatus upon any practical scale. It has been here mentioned to illustrate how misguided ingenuity sometimes runs to complications, while leaving untouched the really essential requirements.

The next inventor to be noticed, M. *Goupil*, a distinguished French engineer, began otherwise: by taking thought of the motive power and of the equilibrium. After having tried a few preliminary experiments, he designed in detail a light steam-engine and boiler, the weight of which he estimated at 638 lbs. for a machine of 15 H. P. gross, or 42.5 lbs. per H. P. He also designed a condenser of like capacity, estimated to weigh some 220 lbs. (15 lbs. per H. P.), so that the water could be used over and over again; and he then figured that the rest of the flying apparatus, without cargo, might weigh 242 lbs., thus making a total of 1,100 lbs., so that if the steam-engine worked up to two-thirds of its theoretical efficiency and developed 10 effective H. P., the total apparatus would have been in the proportion of 110 lbs. per H. P., but might be reduced to about 44 lbs. per H. P. through the use of aluminium instead of other metals.

These estimates of weights of motor and condenser have been since then more than confirmed by the achievements of M. *Maxim* and other inventors, but before seeking to realize them M. *Goupil* determined to investigate the all-important question of equilibrium.

Both observation and mathematical considerations had satisfied him that much of the longitudinal stability of the bird in the air was due to the raking shape, fore and aft, of the under part of its body, which, presenting to the air an increasing and more effective angle of resistance when

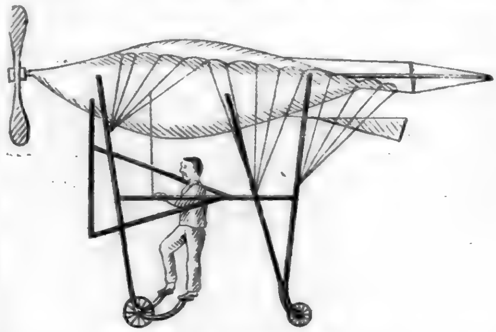


Fig. 62.—GOUPIL—1883.

pitching oscillations occur, tended to restore the balance, and to prevent the animal from taking either a "header" or a "cropper." This he determined to test experimentally, and he accordingly built, in 1883, an apparatus similar to that represented by fig. 62; omitting, however, the screw, the lower framework, and the stays to the wings.

The alar spread was 19.68 ft., from tip to tip of wings, the length was 26.24 ft. from the head tip to the end of the tail, and the mid-section was 26.90 sq. ft. in area, while the sustaining surface was no less than 290 sq. ft., the weight being 110 lbs.

It will be noticed that this was a marked departure from the ordinary aeroplane types, there being an ample body to contain machinery, and the wings being decidedly concavo-convex, while other inventors have generally endeavored to diminish the body as much as possible, and to gain support from various combinations of *plane* surfaces.

M. *Goupil's* object was to make a series of preliminary experiments with this apparatus, in order to ascertain its stability, the effect of the wind upon such a system, and the resistance to be expected, as well as the sustaining power. He accordingly applied neither motor nor screw, but exposed it to the natural wind when blowing from 18 to 20 ft. per second, say, about 13 miles per hour, at which velocity the resulting air pressure is generally assumed to be 0.85 lbs. per square foot. These experiments took place in December, 1883, at which season the winds were quite variable, and the apparatus was anchored by various ropes so as to prevent it from rising more than 2 ft. from the ground.

Exposed head on to a wind of 18 to 20 ft. per second, the body being inclined at an angle of 1 in 10 and the wings at 1 in 6 (about 10°), this apparatus lifted up clear of the ground the weight of two men besides its own, making a total of 440 lbs.! The thrust or end resistance did not

exceed 17.6 lbs. M. *Goupil* tested this several times, and expresses himself as surprised at the low resistance to penetration against the wind evidenced by this apparatus, which was mounted upon two small wheels.

When the wind increased to more than 20 ft. per second he could no longer control the machine. There being no stays or guys to the wings, such as are shown in fig. 62, the apparatus was twisted out of shape, and the wind took greater effect upon the deformed side. Then a wind gust occurred; the efforts of five men were required to control the apparatus, and one of the wings (constructed with white pine) was broken.

The inclement season and other considerations of a personal nature prevented M. *Goupil* from pursuing these experiments further at that time. He had gathered valuable preliminary data, and had caught a glimpse of a very important fact concerning the effect of concavo-convex surfaces, but his own affairs had a more immediate claim upon his personal attention.

He therefore desisted for a while and allowed the subject to remain in abeyance until he could take it up again, but he published, in 1884, a very remarkable book, "La Locomotion Aérienne," in which he advanced a number of important and new theoretical considerations concerning the solution of the problem of aerial navigation, gave data concerning the steam-engine, the condenser, and the various sizes of bird-like aeroplanes which he had designed, and generally evinced such a grasp and comprehension of the question that it seems a marvel that the book is not more frequently referred to by the French writers on aviation.

This experiment of M. *Goupil* opens up quite a new field of inquiry concerning the effects of concave, bird-like surfaces, when exposed to an air current. Calculated by the data which have been gathered by experiments upon plane surfaces, the "drift" and total resistance does not seem to vary greatly from what might be expected, but there is an enormous, an almost incredible increase of the lifting power.

Thus there was said to be a total end thrust of 17.6 lbs. in the apparatus when exposed to a wind of about 13 miles per hour, at which the air pressure would be presumably some 0.85 lbs. per square foot. The angle of incidence of the wings was practically 10°, and we may, without serious error, assume the resistance of the body to have been one-tenth of that due to its mid-section, while that of the edges of the wings (presumably 0.20 ft. in average thickness) would be about one-third of their plane cross-section. As the sustaining surface was 290 sq. ft., we then have, using the table of "lift" and "drift" heretofore given, the following estimate:

RESISTANCE OF THE GOUPIL AEROPLANE.

Drift 10°.......	$290 \times 0.85 \times 0.0585$	= 14.42 lbs.
Body..........	$26.9 \times 0.85 \div 10$	= 2.28 "
Edge of wings..	$19.7 \times 0.2 \times 0.85 \div 3$	= 1.11 "
	Total	17.81 "

which agrees closely with the amount said to have been ascertained by experiment; but when we come to calculate the lifting force we have:

$$\text{Lift } 10^\circ - 290 \times 0.85 \times 0.332 = 82 \text{ lbs.},$$

while the apparatus is said to have actually lifted 440 lbs., or more than five times as much!

Of course various allowances must be made in considering the results of an experiment carried on in a variable wind, and where so little motion of the apparatus (2 ft.) could be allowed. The thrust may have been measured while the breeze was steady, and the uplift to have occurred during a wind gust, deflected possibly by surrounding objects so as to produce a greater angle than 10° with the wings; still, in any case, the result of this experiment and also of other experiments by M. *Phillips*, which are to be described hereafter, leads to the inference that much greater supporting power is to be obtained from concavo-convex surfaces than from the flat planes which hitherto have been chiefly proposed for aeroplanes.

This increase in supporting power might indeed have been expected from the theoretical consideration: that the concave lower surface would produce a higher co-efficient of pressure, while the convex upper surface would deflect the current of air impinging at an acute angle thereon, and thus produce a partial rarefaction; and also from the much stronger practical consideration that *this is the way the wings of birds are shaped*; and yet very few experiments and proposals seem to have been made with bird-like aeroplanes.

This neglect may possibly be due to the fact that the proportions, the shape, the concavity and the convexity of natural wings differ from each other among the various species, so that the moment that we discard the flat plane, a multitude of combinations present themselves, which may require long and careful experimenting before the best shape for an artificial machine is ascertained.

It is understood, however, that M. *Goupil* has planned a whole systematic series of such experiments to elucidate this important matter, and that he hopes soon to be in position to carry them on.

In March, 1884, the *Aéronaute* published a paper by M. *De Sanderval*, giving an account of some very interesting experiments, which he had tried with a pair of artificial wings no less than 39 ft. across and 13 ft. wide in the middle. These wings formed an aeroplane, or *rigid* plane of canvas, stretched upon wooden arms, which latter, however, possessed a certain flexibility.

In a first set of experiments, this aeroplane, loaded with ballast to the amount of 176 lbs., was allowed to glide in calm air along a cable 1,300 ft. long, which both supported and guided it, and which was inclined at a slight angle. It was also allowed to drop in still air from a height of 131 ft., and then still further experiments were tried with men riding on the machine when the wind was blowing.

For this purpose the aeroplane and its operator were suspended by a long rope from the middle of a cable, stretched in some cases between two hills and over a ravine, and in other cases between two high masts erected near the seashore.

M. *De Sanderval* states that he was attached some 5 ft. above the aeroplane and a little in front of its center of figure, so that by pulling upon four oblique cords he was enabled to shift his weight either forward or back, and to the right or left at pleasure.

When the wind blew and the apparatus was restrained by a head-rope, the effect was much the same as when gliding free in calm air, with, however, the unfavorable difference that when near the ground it was less steady by reason of whirling currents.

In a light wind the apparatus would rise until the suspending rope became horizontal, thus relieving it of its weight-carrying function, and the aeroplane would then oscillate at the pleasure of the operator.

When the wind increased to 18 miles per hour the apparatus would sustain the operator and two assistants.

Subsequently, M. *De Sanderval* gave an account of his experiments to the French Academy of Sciences, and this was reprinted in the *Aéronaute* for November, 1886, with the somewhat uncalled-for comment that "it is a pity that the author should not have stated the time, the place, nor the witnesses, as such extraordinary facts need verifying."

The following are the facts as stated:

My first apparatus consisted in two wings, each 19.68 ft. long, thus giving an aggregate spread of 39.36 ft., by a maximum width of 13 ft. These wings were of canvas, stretched upon bamboos and upon wooden arms. The canvas was divided into a series of parallel sheets or flaps, each 4¾ in. wide, and perpendicular to the dorsal line. They were suitably fastened, and a net was stretched above them, so that they might flap and open upon the upstroke, like the feathers of birds, which oscillate upon the quill which divides them into two unequal portions.

Standing upright upon a light board, and connected by straps to a central spine, I was enabled by thrusts of the legs to develop their maximum effort; but with this apparatus, which worked quite well, I was enabled to settle but one fact, and that is, that man cannot develop sufficient energy to sustain himself in calm air. I therefore gave up the thought of beating wings.

I then rebuilt the apparatus, transforming the wings into a rigid plane, and replacing the flapping strips by an unbroken canvas.

This apparatus, weighing 99 lbs., and loaded with 176 lbs. of ballast, was caused to glide under a cable 1,300 ft. long, stretched between two bluffs. There was no deflection in the

cable when the aeroplane glided across at speed, but the deflection was about 26 ft. when the apparatus was stopped in the middle.

If then released (by tripping a hook) it would at first drop almost vertically; then after the first second it would glide forward at increasing speed, while the rate of vertical fall diminished; but upon the slightest disturbance in the equilibrium, consequent upon any divergence between the center of gravity and the center of pressure, the inert ballast would aggravate the oscillation, and the apparatus would plunge down to smash. It seemed evident to me that if intelligence were applied to regulate the position of the center of gravity, steady progression would result.

I then suspended the apparatus by a long rope attached in the middle of the cable, and substituted my own person for the ballast. I found that with an intelligent live control the apparatus would oscillate in the wind according to my pleasure, as I have already indicated in a previous communication. The supporting surface of 301 sq. ft. sufficed to sustain a man at a comparatively slow rate of fall, and by a wind of 22 miles per hour it lifted me up with two assistants, and sustained us in the air during the entire period that we kept the holding-back line taut, by maintaining a proper angle of incidence.

The last and more interesting experiment which I attempted was based upon these previous results, and also upon the fact that soaring birds can rise into the air on a helical path, or else maintain themselves a long while at the same altitude without beating their wings, provided always that they possess sufficient horizontal speed as regards the air. I therefore experimented with an apparatus somewhat similar to the preceding, but round in shape, suspended by a vertical rope 650 ft. long,* and caused it to swing around in a circle, so that the suspending rope described in its path the outer periphery of a cone. In this experiment I could feel a notable reaction against my weight, but it required a much longer suspending rope to allow so large an apparatus to swing in a circle of sufficient diameter to permit its gaining the necessary speed, and to manœuvre freely. I believe, however, from the feeling that I had really taken possession of space within the limits of my somewhat irregular speed, produced upon my mind by the experiment, and also, from my observations of soaring birds advancing against the wind on rigid wings, that man can succeed in reproducing sailing flight.

If one had an unlimited height to fall in, affording plenty of time to think and to act, he would probably succeed in guiding himself at will. In calm air man does not possess sufficient energy to sustain himself, but either in a sufficient wind, or with a proper horizontal speed of his own, he finds himself under different circumstances, and derives from the air quite enough supporting power. It is through the operation of this dynamic equilibrium that he will eventually succeed in compassing practical flight.

I caused to be constructed, from manuscript notes furnished by M. *Biot*, a very ingenious apparatus intended to comply with the above conditions, and I experimented with it. This apparatus consisted in two great wings supported on a light carriage, which gained its initial speed by rolling down a long incline covered with an asphalt floor. It rose into the air pretty well, but always with the disadvantage that the experiment could not be sufficiently prolonged to furnish decisive results; each time upon coming down the apparatus was injured.

It appears to me that a long, vertical rope, such as that previously described, swinging around so as to describe a cone of extended base, must afford greater chances for careful experiment and for eventual success.

The writer has been unable to find any further records of experiments by M. *De Sanderval*. He seems to have been baffled by the lack of means to maintain equilibrium, but even had he possessed the appliances and the skill to bring the center of gravity to coincide with the center of pressure, as often and as fast as the angle of incidence changed, it may be questioned whether he could have acquired, without a very long apprenticeship, that instinctive use of them which constitutes the science of the birds.

It is inferred from the description that M. *De Sanderval* experimented with plane surfaces, although it is possible that under the action of the wind they may have assumed those concavo-convex shapes which we have seen to obtain with the birds and to be more effective than flat planes. In any case, he is to be commended for having made an earnest if unsuccessful effort *to learn how to soar in a wind like a bird*, the possibility of which performance for man will be further discussed hereafter.

* Stated at 200 meters: may be a misprint.]

In 1884 M. *Armour*, the author of several papers which will be found in the reports of the Aeronautical Society of Great Britain, patented a flying machine, in which he proposed the use of aeroplanes or wings, oscillating upon springs transversely to the line of motion, these wings being set behind each other as well as superposed. It is not known whether any experiments were tried with this curious device, which seems to be a combination of fixed wings (or aeroplanes) with oscillating wings, but it seems doubtful that it can prove efficient.

There was a second aeronautical exhibition in 1885, under the patronage of the Aeronautical Society of Great Britain, but the total number of exhibits was only 16 as against 78 in 1868.

Among these exhibits the model which attracted most attention was that of M. C. *Ring*, of Denmark, which consisted of an aeroplane with a pair of arched wings, somewhat similar in the front-edge view to the arched wings of the gull and of the albatross. In plan, however, these wings were rectangular instead of the approximately triangular shape which obtains with the birds. These aeroplanes were to act as sustaining surfaces, the angle at which they met the wind being determined by the position of a large flat tail, and the propulsion being furnished by four wing-propellers oscillating beneath the aeroplane, and driven in the model by twisted rubber.

The apparatus was supported by a string fastened vertically above its center of gravity to the crosspiece of a light framework. It propelled itself slowly, but was incapable of free flight, probably in consequence of defective equilibrium.

M. *Ring* also exhibited a model of a gun-cotton engine in which small charges were to be exploded between two pistons, moving in opposite directions in a long cylinder; but the model was not a working one, and no attempt was made to construct a full-sized engine.

Reference has already been made to a "trunk steam-engine," shown by M. *S. Hollands* at this exhibition. He gave a description of this and of two other types of light steam-engines with which he had experimented, at subsequent meetings of the Aeronautical Society of Great Britain.

The first was a "direct-acting" engine, rotating at high speed *twin* vertical screw fans (right and left) in opposite directions, and a model of this machine, developing $\frac{1}{16}$ H. P., was said to have weighed 6 oz. for the engine and boiler, or at the rate of only 6 lbs. per horse-power. It was first intended to generate the steam by burning liquid fuel, but M. *Hollands* subsequently concluded that hydrogen gas, carried highly compressed in a suitable reservoir, and burned with an admixture of twice its volume of air, would prove preferable for lightness and heating efficiency. He estimated that the weight of this type of motor, including not only the engine and boiler, but also the water therein, the fuel-gas reservoir and the driver's stand, would be 11.5 lbs. per indicated horse-power.

The other engine was "geared" so as to rotate two right and left fans on *concentric* vertical shafts, one inside of the other, through the intervention of toothed mitre gear. The function of these two vertically superposed fans was to lift only; a smaller horizontal fan being carried on a prolongation of the crank-shaft, and its thrust aided by the reaction of the exhaust steam ejected through a suitable nozzle. The weight of this engine per horse-power is not stated.

Both these arrangements, it will be observed, involved discharging the exhaust steam into the air, and thus wasting some 20 to 22 lbs. of water per horse-power per hour, M. *Hollands* not seeing his way to adding an aerial condenser (to recover the steam) in any form, within any admissible limits of weight. He stated that the power necessary was one indicated horse-power for every 30 lbs. of the whole weight, so that without a condenser the flight of such an apparatus as he proposed would have been limited by the very small quantity of water which it could lift.

M. *Hollands*, however, made some experiments on the best form of lifting screw-blades, and stated that he had found it advantageous to make the fan blade concave on the driving or lifting side, and that the angle of maximum efficiency

was 15° with the plane of motion at the tip, and 30° at the root. The form which he found most efficient was two-bladed; with the blades narrowest at the tips, slightly concave on the lifting side, the tip slightly drooping, each blade being approximately the shape of an elongated shallow spoon or scoop, and with a pitch equal to about two-thirds of the fan's diameter, giving a mean angle of blade of 22° 30′ with the plane of motion. These blades were of thin sheet steel, and their forms will be noted as confirming what has already been stated as to the advantages of the bird-like form of wing. M. *Hollands* said further:

I find another advantage accrues also from the use of these very thin, sharp edged hollow blades—viz., that there is *no appreciable resistance to rotation that does not contribute to lifting effect.* A marked contrast to this desirable quality is presented in the results given by *flexible bladed* fans, constructed to *vary their pitch* automatically, being normally of *coarse* pitch (when still), but decreasing their pitch when rotated, and further decreasing it with increase of speed. Some experiments I made with fans of this description showed an unmistakable loss of power, as compared with the other type above described, due apparently to the energy absorbed in deflecting the elastic blades; which deflection, with a given speed, causes a constant strain and resistance, with no compensating useful effect.

In 1888 *W. Beeson* patented, in the United States, the singular soaring device shown in fig. 63. He had already patented, in 1881, a soaring apparatus consisting of two or

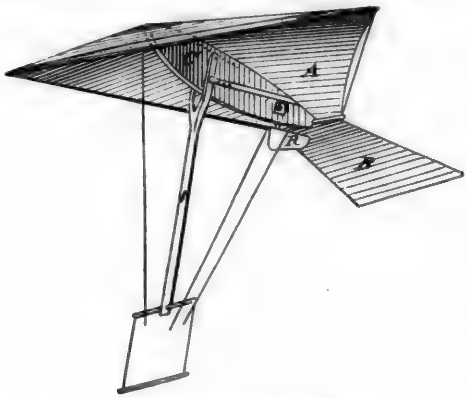


Fig. 63.—BEESON—1888.

more sets of adjustable superposed sails stretched on inverted A frames, which he expected to raise into the air like a kite, and then sail upon the wind, but he apparently abandoned this device in favor of the simpler form shown in fig. 63.

This consisted in a mainsail *A* and a tail or back-sail *B*, both of which were supported on a plate or board *C*, ranging fore and aft. This plate was convexed at its upper edge so that the sail *A* might extend over, forward and downward to a cross-bar forming the front edge, and thus enclose a head pocket to catch the wind. A forked pendulum-bar, *I*, was pivoted to the plate *C*, and it supported at its lower end a trapeze arrangement to carry the operator, who by means of three light cords extending to his hand might alter the angle of incidence of the mainsail *A*, of the tail *B*, or of the rudder *R*. The mainsail and tail being, moreover, connected by an adjustable bar, which caused the mainsail to act upon the tail automatically, so as to maintain the equilibrium at all angles of incidence through the compound lever thus formed.

M. *Beeson* states in his patent that "this machine is self-supporting in a light wind, say, of 10 miles or more per hour, and that when once raised by a kite or otherwise, and cut loose, it will of itself perform the evolutions of a soaring bird and rise to any altitude."

The writer confesses that he has tried the experiment with a small model and has failed; and so, in the hope that some of his readers may be more fortunate, he has given this account of what seems to be a remarkably simple device—if it will work.

(TO BE CONTINUED.)

COLUMBIAN EXPOSITION NOTES.

The most approved methods of artificial ice making and cold storage will be exhibited at the World's Fair. These processes will be shown in a very fine building, 130 × 255 ft., and five stories high, with observatories at the corners and a lofty tower at the center. About 80 tons of ice will be manufactured daily, three methods being employed—namely, the plate system, from filtered water; the can system, from condensed steam filtered and purified; and the can system from de-aerated water. Three different processes of cooling rooms will also be shown.

Ohio will erect a mineral cabin in the Mines Building at the World's Fair to illustrate its mineral resources. The cabin will be 32 × 61 ft. in dimensions and 23 ft. high, and be constructed entirely of Ohio mineral products.

The Machinery Department of the World's Fair, at Chicago, will be an interesting one to mechanics. The Egan Company, of Cincinnati, the famous builders of wood-working machinery, will make the finest display ever made in that line. Some novel time and labor-saving machines will be shown in practical operation.

Among the questions suggested for discussion at the Electrical Congress in Chicago next summer are the following of general interest:

Comparison between procedure in different countries.

Methods of avoiding electrical interference, and risks to persons and property.

Units of magnetic quantities, and mode of embodying them in concrete standards.

International nomenclature for describing phenomena of alternate currents and of electro-magnetic waves.

National and municipal testing laboratories.

Materials for standards of electric resistance.

Points of difference of the electrical vocabulary used in different countries.

The direct conversion of the energy of fuel into electric energy.

Comparison of the various methods employed for the electric transmission of power.

The cost of insulation in relation to high pressure for the electric transmission of power.

Comparison of the economics of the various systems of electric distribution.

Electric traction.

Application of electric power in mining.

Commercial instruments for measurement of electric quantities.

The electric working of metals.

The use of electric and magnetic tests for ascertaining the mechanical properties of metals and alloys.

The best material and mode of erection of lightning conductors in the light of recent researches in electric discharges.

The prospecting for iron by magnetic surveys.

International telegraphy.

Fast-speed and long-distance telegraphy.

Telegraphic lines, land and sea.

Harmonic telegraphy.

Writing telegraphs.

Long-distance telephony.

The possibility of providing telephonic communication without wires.

Application of electric signaling to the working of railroads (alarms, time, etc.), and to naval and military purposes.

Magnetic separators.

The use of electricity in engraving and in art reproductions.

Besides these, a large number of questions are suggested which are purely technical, and therefore of interest only to electricians.

IRRIGATION IN INDIA.

(Translated from *Mémoire* by Chief Engineer Barois, in *Les Annales des Ponts et Chaussées.*)

(*Continued from page 23.*)

It has already been stated that there are in India two classes of canals: Inundation canals, which are only fed during the floods; and irrigation canals, which are supplied with water at all seasons. The canals of the latter class are the most important and interesting, and it is of these only that mention is made here.

It is not easy to point out any established rules for the section or profile of these canals, which naturally vary according to local conditions. Generally the section of the principal canals seems to be so arranged that the depth of water shall be from 6 ft. to 10 ft. The fall is variable; but it seems to be assumed that the minimum rate of flow to prevent deposits and the growth of aquatic plants should be about 1¼ ft. per second.

There is, however, one very essential precaution. The rivers of India are generally heavily charged in time of flood with matter in suspension, and, to avoid heavy expense in cleaning out the canals, it is necessary that this matter be carried as far as possible to the land irrigated, and not deposited in the canals. All retarding causes in the main canals must therefore be avoided, and the fall in the secondary or distributing canals should be somewhat greater than in the main canal. The work of cleaning out the small distributing canals is easier and less costly than that for the main canals.

The section of course varies with local conditions and local needs.

Many of the main irrigation canals are also used for navigation. In this case the fall must be regulated so that the current will not interfere with the passage of boats, and all dams must be provided with locks.

Some examples of the greater canals are given in the accompanying sketch maps. Fig. 9 shows the Upper Ganges Canal, the Eastern and Western Jumna canals and the Agra Canal.

The Upper Ganges Canal, which extends from the Myapore Dam to Cawnpore, is 181 miles long; its chief branches are 410 miles in length, and they supply a system of distributing canals having a total length of about 3,400 miles and supplying water to 950,000 acres of land. The main canal is 160 ft. wide at its head, and receives from the river an average of 6,000 cub. ft. of water per second in summer and 3,600 cub. ft. in winter. The depth of water is 10 ft. with the maximum delivery.

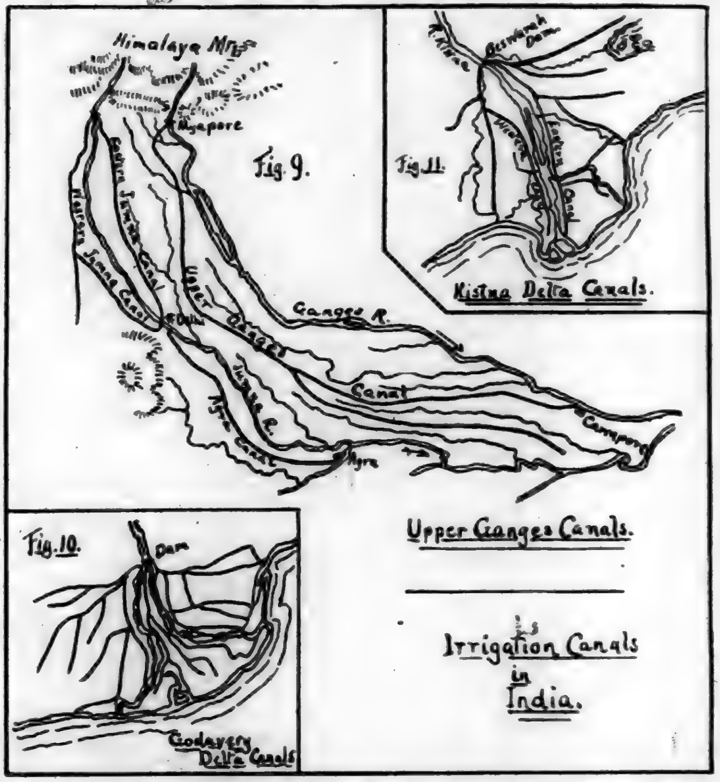
The Eastern Jumna Canal receives usually about 1,250 cub. ft. of water per second from the Jumna; the main canal is 130 miles long, supplying about 625 miles of distributing canals, which irrigate 210,000 acres. The Western Jumna Canal is 102 miles long, has 313 miles of large branches and supplies 515,000 acres. It takes from the Jumna an average of 2,500 cub. ft. per second.

The Agra Canal, which also receives water from the Jumna River, extends from a point near Delhi to Agra, 140 miles; its distributing system includes about 310 miles of branches. At the head this canal is 70 ft. wide and 9 ft. deep; it receives an average of 1,975 cub. ft. per second.

The Lower Ganges Canal is 213 ft. wide and 10 ft. deep at the head. It is 313 miles long, has 846 miles of large branches, and supplies water to 525,000 acres of land. Of this system 684 miles are navigable.

In the Punjab the Bari-Doab Canal, which takes water from the Ravi River, the chief tributary of the Upper Indus, is 140 miles long; it supplies water to 220 miles of large branches and 830 miles of distributors, irrigating 550,000 acres. Of this system 190 miles are navigable.

A peculiar system is that of the Godavery Delta, shown in fig. 10. It includes three main canals, numerous branches and a system of distributing canals which supply 900,000 acres. The Kistna Delta has a somewhat similar system, shown in fig. 11. Two main canals start from the Beswarah Dam, and through a network of branches and distributors irrigate nearly 1,400,000 acres.



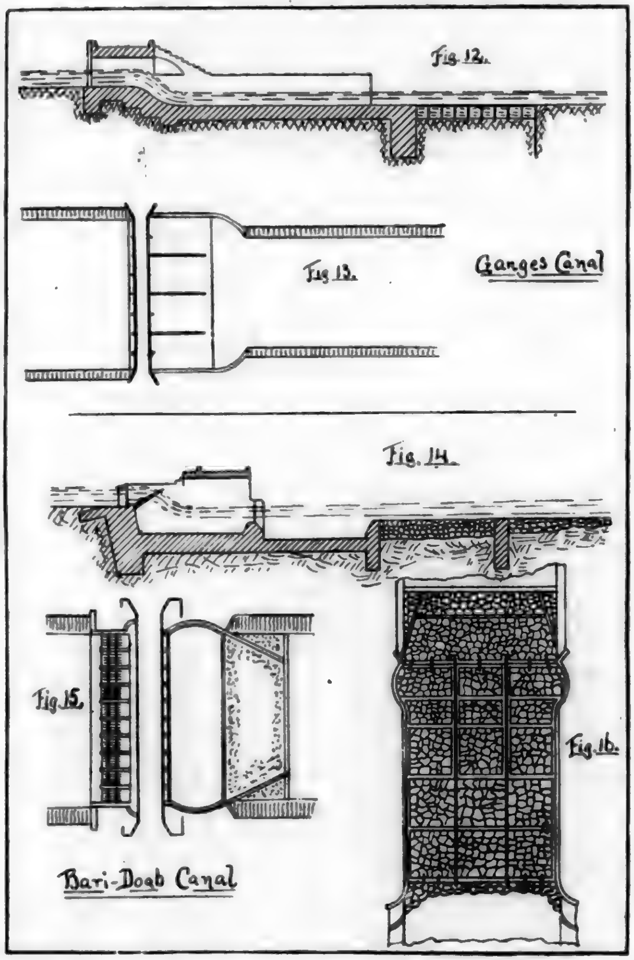
Other works of this class which deserve mention are the Orissa canals in the Mahanuddy Delta, and the great Sirhind Canal in the Punjab, recently completed.

The head-works of the canals as a rule consist of piers of masonry supporting sliding gates, which serve to regulate the delivery of water. They have masonry foundations, protected above and below by rip-rap. On the Upper Ganges Canal the piers are 20 ft. apart, but the gates are too large to be easily handled, and in most cases the openings are not over 8 or 10 ft. Similar works are frequently placed at other points, where it is desirable to regulate the flow of the water, or to divert it to branch canals.

In deltas or the lower parts of river valleys, where the natural fall is slight, the distributing works are usually found sufficient to regulate the flow of water and keep it below the point where corrosion of the banks is likely to occur. Where the natural slopes are greater the excessive fall is overcome by inclined planes or chute walls at intervals across the canal.

A work of this class on the Upper Ganges Canal is shown in section in fig. 12 and in plan—on a smaller scale—in fig.

13. The fall here is 8 ft., and the bed of the canal is of masonry for about 120 ft., the foundations consisting of rows of wells sunk in the clay soil. At the upper end, just above the chute, is a bridge of eight arches of 24 ft. span, the piers having a thickness of 4½ ft. To regulate the flow and keep it parallel with the channel, three of the piers are continued 85 ft. below the bridge. The bank walls or abutments are carried still further, and are curved inward at the ends, as shown in fig. 13, in order to throw the current toward the center of the canal and prevent corrosion of the banks.



These works have the drawback of increasing the velocity of the current and lowering the water level above them too much, and to prevent these results various plans have been tried, with more or less success.

A plan adopted on the Bari-Doab Canal is shown in section in fig. 14 and in plan—on a smaller scale—in fig. 15. Here the chute wall is nearly vertical, and below it is another vertical wall, the object of which is to check the current and provide a cushion or bed of water to lessen the force of the fall. A bridge is carried across the canal by masonry arches, the piers of which divide the flow into openings of 10 ft. each. The openings are greater than the normal width of the canal, and the abutments are carried below and turned inward as shown in fig. 15. A special arrangement is used here to break the force of the current. It consists of a sort of grating of wood held in place by an iron frame; this is shown in section in fig. 14 and in plan in fig. 15. This grating breaks up the current into small streams, and is found to serve well in keeping up the level above the fall; it serves also to hold the larger débris carried down the canal, which can be removed from time to time as required. Below the masonry foundation the canal bed is protected for some distance by rip-rap.

In several places on the Bari-Doab Canal the fall is secured by inclined planes. One of these is shown in plan in fig. 16. Here the bed of the canal is of rip-rap, the stone being kept in place by transverse walls of masonry, dividing the bed into rectangular spaces as shown. Wing walls are built along each bank to direct the current and prevent corrosion.

In Southern India the general practice is to use a vertical chute, and to reduce somewhat the waterway at the chute.

In Northern India, especially in the sections near the mountains, the canals frequently meet streams which must be crossed or diverted. Where these are of small size they are simply turned into the canal; but in many cases they must be carried over it by an aqueduct, or under it by a siphon. Some of these works are of considerable size and importance. Where the Ranipore crosses the Upper Ganges Canal there is a receiving basin covering 80 acres, from which a passage consisting of several parallel arched culverts of masonry leads under the canal. On the Agra Canal the overflow from the Mandampoor Reservoir is carried over the canal by an iron aqueduct supported by girders resting on stone piers.

There are a few places where such arrangements are not possible. At Dhanauri, on the Upper Ganges Canal, such an instance is found, where the Ratmu Torrent crosses the canal at a level. Here the stream is led into a receiving basin covering about 83 acres, from which the water passes into the canal by a series of gates which can be closed when required. On the opposite side the water passes out of the canal by a series of openings of various depths, which can also be closed by gates working between masonry piers. Below the crossing is a regulating dam. This crossing is only used at high water; in the dry season, when the flow of the Ratmu is small, the surplus water is carried under the canal by two masonry culverts forming a siphon.

There are several cases where canals can be carried above the streams by aqueducts. One of this kind is found where the Upper Ganges Canal crosses the Solani River at a height of 35 ft. above the river-bed.

This aqueduct is a masonry bridge 920 ft. long, having 15 arches of 50 ft. span; the piers are founded on wells sunk in the river-bed. The aqueduct is divided by a longitudinal wall into two channels; it usually carries a depth of 10 ft. of water.

Another interesting aqueduct is carried across a branch of the Godavery on 39 arches of 40 ft. span. The channel of this aqueduct is 23 ft. wide and it usually carries a depth of 6 ft. of water. Its bed is of concrete covered by a layer of clay.

Of course there are many other works along the line of the canals, such as bridges, locks for the passage of boats where the canals are navigable, and others of various classes; but no description of these is necessary, as they have no special relation to irrigation.

It may be noted that the fall produced by regulating or other works is often used to run the native grist-mills.

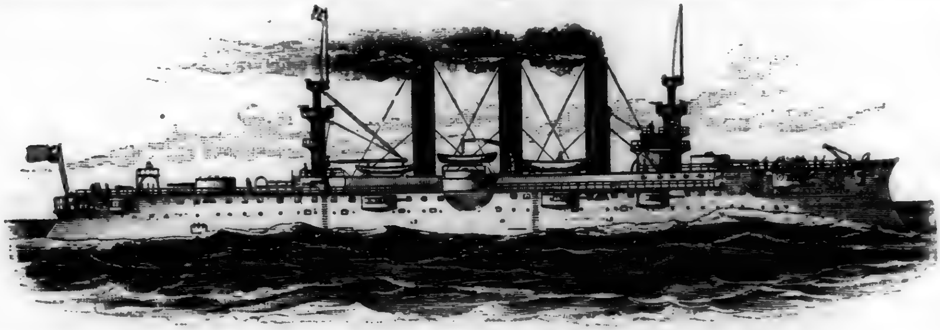
Many drainage works have been executed to carry off surface water and the surplus water of irrigation, and to improve lands adjoining the canals. These works are of various kinds and classes.

It may be mentioned that one difficulty is found in the neighborhood of many of the canals. In consequence of the evaporation at the surface of the soil of the water of infiltration from the canal, there are left saline efflorescences which are difficult to remove, and which make the land sterile.

HOME NAVAL NOTES.

THE contracts for the new armored cruiser *Brooklyn* and the battle-ship *Iowa* have been let to the William Cramp & Sons Company in Philadelphia, whose bids on both ships were the lowest.

The general appearance which the *Brooklyn* will present is shown in the accompanying sketch, from the *Iron Age.* The great height of the smoke-stacks is perhaps the most marked feature.



DESIGN FOR NEW ARMORED CRUISER "BROOKLYN," FOR UNITED STATES NAVY.

The *Brooklyn* is of the same general type as the *New York*, but somewhat larger. Her dimensions are: Length on load-line, 400.50 ft.; extreme beam, 64.83 ft.; mean draft, 24 ft.; displacement, 9,150 tons. She will have four triple-expansion engines, intended to work up to 16,000 H.P. and give a speed of 20 knots an hour. The normal coal capacity will be 950 tons, and 1,650 tons can be stowed when needed.

The armor will include a 3-in. water-line belt, a heavy protective deck, 8-in. barbettes and 5½-in. turrets for the guns of the main battery, besides heavy shields for the other guns.

The battery will consist of eight 8-in. breech-loading rifles; twelve 5-in. rapid-fire guns; twelve 6-pdr. and four 1-pdr. rapid-fire guns; four machine guns and two field or boat guns. The 8-in. guns will be mounted in the turrets on the barbette and will have a wide arc of fire. There will be five torpedo-tubes, one in the bow and two on each side.

The ship will have a radius of action at full speed of 1,792 knots, and a cruising radius at 10 knots of 6,216 knots.

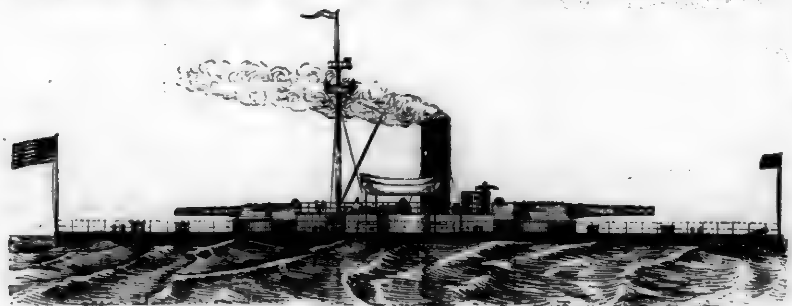
The hull and fittings were designed by the Bureau of Construction and Repair, under the direction of Chief Constructor T. D. Wilson, U.S.N., and the machinery by the Bureau of Steam Engineering, under the direction of Engineer-in-Chief George W. Melville.

TRIAL OF THE "MONTEREY."

The official trial of the new coast-defense ship *Monterey* took place January 5 in the Bay of San Francisco. The official report has not yet been made public, but it is understood that on a four hours' run the main engines averaged 162 revolutions and developed 5,450 H.P. The auxiliary engines will add about 150 H.P. to the total. The average speed was about 14¼ knots and the maximum 15 knots. The engines worked well both on the natural and forced draft trials.

The accompanying cut of the *Monterey* shows the vessel as originally designed by the Bureau of Construction. The only material change since made is the substitution of 12-in. guns for the 16-in. guns originally proposed.

The special feature of the *Monterey* is the use of the Ward tubulous boilers. These worked very well on the trial, furnishing all the steam needed.



COAST DEFENSE SHIP "MONTEREY," UNITED STATES NAVY.

IT is said that the question of building the torpedo cruiser authorized some time ago in one of the navy-yards has been considered; but it is probable that nothing will be done unless Congress should authorize an increase in the amount appropriated for her construction.

DESIGNS are in preparation for the four torpedo-boats or launches which are to be carried by the *Maine* and the *Texas.* These boats will be about 60 ft. long, 9 ft. beam and 15 tons displacement. They will have Ward tubulous boilers and quadruple-expansion engines of 200 H.P.; their calculated speed will be 18 knots.

THE largest contracts for armor-plate ever let in this country will shortly be given out. A little over 7,000 tons of plates of various sizes and thickness will be needed for the ships now authorized. It is thought that the contracts will be divided among several firms.

AN appropriation of about $2,500,000 will be asked for this year to continue the work already begun on coast defense works at New York, Hampton Roads and San Francisco. The plans for these works are now completed, and a beginning has been made, but new appropriations are needed to carry on the work.

THE BALTIMORE & OHIO RAILROAD'S EXHIBIT AT THE WORLD'S FAIR.

During a recent visit to Baltimore, we had the pleasure of inspecting the exhibit which the Baltimore & Ohio Railroad Company is preparing for the Columbian Exhibition under the supervision of Mayor J. G. Pangborn. The exhibit is to be designated "The World's Railway; Its Conception, Inception and Perfection; Its Motive Power, Equipment and Appliances."

The following excellent description of this exhibit is condensed from one which the New York *World*, with commendable enterprise, published in its issue of January 8.

With the proposed exhibit in view, Major Pangborn, accompanied by his Chief of Construction, William G. O'Brien, made an extended tour of Europe last year. The interest aroused by them, the personal attention drawn to the plans of the Baltimore & Ohio and the broad and liberal basis upon which the company proposed proceeding secured the hearty aid of such institutions as the South Kensington Museum, of London; the Conservatoire des Arts et Metiers, of Paris; the National Museum, of Vienna, and the Edinburgh Museum, of Scotland. In these are treasured the oldest and most important examples of steam locomotion now in existence. From these drawings full-sized models of the engines have been made in wood, the different working parts being arranged to move, as they did in the actual engine, when the model is rolled on the track prepared for it. The wood is painted to imitate metal, and so close is the imitation that at a few feet from the model it is impossible to tell whether it is made of wood or iron. These models are as exact reproductions as it is possible to make of those historical engines from the most careful measurements of originals, the institutions named having the working drawings especially prepared and forwarded for the purpose. The models have been made in a building at the west end of Baltimore Street, which is occupied as a workshop, and is filled with a corps of pattern makers and draftsmen.

PRIMITIVE LOCOMOTIVES.

The Messrs. Stephenson were induced for the first time to permit tracings to be made directly from the original drawings by George Stephenson of some fourteen of his earliest locomotives. Three of Stephenson's locomotives—his first, the *Blucher* (1816), his famous *Rocket* (1829), and the highest type of his *Planet* class, the *Mercury* (1830)—have been duplicated full size from his original drawings.

From the measurements and drawings sent on by the Conservatoire of Paris full-size reproductions have been made of the oldest example of steam locomotion in existence, that of Cugnot (1769), and of the first locomotive in the world with multitubular boiler, that of Seguin (1827).

Likewise, from measurements of originals and following the working drawings prepared under the supervision of the South Kensington Museum, full-size reproductions have been made of the *Puffing Billy* (1813), the first locomotive with smooth wheels for smooth rails, and the *Sans Pareil* (1829), the first introduction of the steam blast. The *Puffing Billy* is the oldest locomotive existing.

Two grandsons of Timothy Hackworth, the designer and builder of the *Sans Pareil*, who recently visited Baltimore to inspect the reproduction, say it is difficult to tell the duplicate from the original.

EVOLUTION OF STEAM PROPULSION ON LAND.

The few of the full-size working reproductions enumerated embrace but a small section of the whole. The exhibit begins with the first method of propulsion by steam on land—that of Sir Isaac Newton in 1680; thence the evolution is indicated through the Cugnot (1769), the Murdoch (1784), the Read (1792). The latter, by the way, was the first steam wagon in America, and its designer; Nathan Read, of Salem, Mass., was the inventor of the multitubular boiler, without which the locomotive of the present day would be an impossibility. Following the Read comes the first Trevithick, the initial design (1800) of the father of the locomotive, Richard Trevithick, a Cornish colliery foreman. In 1803 he built the first locomotive that ran upon a rail. Attached to the full-size reproduction of this first of all locomotives will be the two original little flat cars it drew upon the South Wales colliery road.

A remarkable copy is that of an invention by Oliver Evans, who in 1804 accomplished in Philadelphia propulsion on land by steam. It was a queer-looking thing for surface travel, and never intended for such, being in reality a dredger. But Evans propelled it by gearing from his engine to temporary wheels, and although it weighed upward of 40,000 lbs., propelled it successfully through the city streets to the Schuylkill River.

Up to this time no steam carriage or wagon on common roads, or the Trevithick locomotive on rail, had done much more than move with its weight, which in no instance exceeded a third of that of the Evans make.

Others in the series are the Trevithick (1808), the Brunton (1811), the Blenkinsop (1812), the Hedley (1813), the *Novelty* (1829), and the *Stourbridge Lion* (1829), the last named the first locomotive to turn a wheel in America. It did little more than turn a wheel, and the Cooper, on the Baltimore & Ohio the year following, was the first locomotive built on the American continent.

WEEDING ERRORS FROM HISTORY.

Major Pangborn, his Chief of Construction, Mr. O'Brien, and his Chief Draftsman, Mr. Wright, encountered great difficulties not only in the meagerness in many instances of obtainable facts, but in conflicting and incomplete drawings. Books follow books, one copying from another repeats inaccuracies, and an illustration, made probably largely from imagination originally, gets to be regarded as standard when, if those who used it had taken time to investigate, they would have found that by no principle known in mechanics could such construction as is delineated be made to work.

Months have been spent in going through old records, hunting up old data and tracing information of importance. Abroad most of the links in the chain of historical development have been preserved.

In this country the people who have made history have frequently been too busy creating it to note its recording. Fortunately, the World's Exposition coming when the pioneers of the American railroad have not all been forgotten, there is an earnest endeavor to establish history, and the part the Baltimore & Ohio is taking in this important field will possibly be even more generally appreciated in the future than at the present time.

In no line of research has keener interest been maintained than in following the trial of the locomotives which took part in the Baltimore & Ohio competition of 1831. Of the similar trial of locomotives on the Liverpool & Manchester Railway in England, a year and a half before, every detail is preserved in books, but of the Baltimore & Ohio trial, the second in the world and the first in America, no connected account has been published, and not an illustration or drawing of any of the five locomotives designed and built in response to the company's offer of $4,000 in prizes is known to be in existence.

In uncovering facts in connection with the contest, the files of newspapers of that day preserved in historical societies and libraries of Maryland, Pennsylvania and New York were laboriously gone over, and in order to embrace every possible source of information, advertisements were inserted in Pennsylvania and New York papers seeking communication with the descendants of those who designed and constructed the engines. Old employés of the company have been interviewed, and in every way were the inquiries pushed, until finally the long and painstaking delving was rewarded with such results as to enable the building in perfect fac-simile of all five locomotives. No single event in the railroad history of America could have been of higher historical value to establish than this.

IMPORTED LOCOMOTIVES.

The Baltimore & Ohio was the only pioneer railroad of this country not taking foreign models for locomotive construction or importing foreign locomotives for service. It has been generally supposed that the half dozen or so well-known English locomotives comprised the importations for

American roads, but data recently discovered by Major Pangborn's representative in England prove that up to 1840 no less than 68 English locomotives were sent here.

The *Stourbridge Lion*, built by Foster, Rastrick & Company, was the first locomotive placed upon a track in this country, but not the first ordered for use here. The *America*, built by George Stephenson, was the first, and it reached these shores ahead of the *Lion*.

An example of the little care and thought given to fact is instanced in the so-called model of the *Stourbridge Lion* in the National Museum at Washington. With the boiler, one of the cylinders and the wheels of the original locomotive in immediate juxtaposition in the museum, the model presents a most peculiar study, inasmuch as it varies so widely from the original in its parts as to cause one to wonder whether the man who designed the alleged reproduction ever gave himself the trouble of following anything but his imagination. Yet the illustration made from this inaccurate model is generally accepted and published as the *Stourbridge Lion*.

As has been stated, no foreign engine was employed or even tried on the Baltimore & Ohio, the ruling disposition of its management being to encourage and develop American genius. To such end it offered in January, 1831, the, for the time, large money prizes for competing locomotives. A striking feature of the engines entering the trial was that not one of the five was copied from the foreign model or was at all like another. While none of them, not even the *York*, the winner, was strictly successful, they evinced the originality and independence ever since characteristic of American builders.

As to the matter of not subsequently following the construction of the locomotives participating in the Baltimore & Ohio trial, the sequel was no different than that of the Liverpool & Manchester competition. With all the fame of the *Rocket*, Stephenson never built another locomotive like it, nor did Hackworth duplicate his *Sans Pareil* or Ericsson his *Novelty*.

All the locomotives entering in the Liverpool & Manchester trial, as well as those taking part in the Baltimore & Ohio trial, will be shown in full-size reproductions.

AMERICAN INVENTIONS.

As development in Europe will be thoroughly depicted, so will American development and progress. The first locomotive in actual service in this country, the first locomotive built here for the first railroad in New York State, the first built by Baldwin, the first built in New Jersey, Rogers's *Sandusky*, the first built by Ross Winans, the first built by the Baltimore & Ohio Company, the father of the standard eight-wheel American locomotive, the first eight-wheel engine built by Ross Winans and the latter's original "camel" locomotive, the first of the type of big fire-boxes will all be shown in full-size reproductions, so that they may be studied in every detail of construction.

Two-thirds of these important historical examples have been completed.

To Ransom C. Wright, of Philadelphia, for a long term of years Chief of the Designing and Drafting Department of the Baldwin Locomotive Works, Major Pangborn assigned many arduous tasks, among them the perfecting of the working drawings for the reproductions of the locomotives in the Baltimore & Ohio trial, and of Ross Winans's first effort.

OLD "GRASSHOPPERS" AND THEIR ENGINEERS.

In the way of original old engines the Baltimore & Ohio possesses the most valued historical examples of American progress in existence. Four of the original grasshoppers are still at Mount Clare, the company's shops in Baltimore, and as none were built subsequent to 1836, not one of the quartette is less than 57 years old. All were in active service until two were recently withdrawn to make the comparatively few changes necessary to restore them to original form, one to correctly reproduce the *Atlantic* (1832), the first "grasshopper," and the other the *Traveler* (1833), the second grasshopper and the first distinctively freight engine built in this country.

The third of the old grasshoppers has just been withdrawn from service in Mount Clare yard; as Ross Winans in 1837 altered a grasshopper by changing the cylinders from vertical to horizontal, and thus created the first of the "crab" type, the *Mazeppa*, so will this one be changed to represent the original.

The fourth of the old engines will remain at work in the yard till the middle of April, and then be taken to Chicago just as it is, and shown after 60 years' continuous actual service, its history having been traced back to 1833 as the time she was placed upon the road. This gives it a record without parallel in the world.

It is probable that the only example of the early type of the once noted New Castle locomotive is the *Dragon* (1848), which has been preserved by the Baltimore & Ohio, and the same is quite likely true of the Mason of 1853, which, although condemned to the scrap heap several years ago, was saved from destruction by a thoughtful hand.

WILLIAM MASON.

No man did more for the efficiency and shapely form of the American passenger locomotive than William Mason. That one of his earliest engines still exists is a source of gratification. It and the *Dragon* are both being restored to their original form, as is also the old Perkins ten-wheeler of 1863 and the "600," which was the Baltimore & Ohio's model locomotive in the company's exhibit at the Centennial Exposition in 1876. The Perkins was of the earliest type of the tremendously powerful freight locomotives built by the company especially for service upon heavy grades. The "600," also built by the Baltimore & Ohio, was the first Mogul passenger locomotive constructed.

THE FIRST MOUNTAIN CLIMBER.

An exceptionally interesting and valuable historical locomotive has been contributed to the exhibit by Walter Aiken, President of the Mount Washington Railroad—the original *Peppersauce*, built in 1865, the first locomotive to ascend Mount Washington. It is a rare relic and is now in the hands of the Concord & Montreal Railroad, that company having it in shop for such preparation as may be necessary to show it in complete original form at the Exposition. It will shortly be shipped to Major Pangborn, and with it some of the original rails, so that when seen it will be in position as when ascending, and standing upon the first rails ever rolled for a mountain railroad.

RAILS AND ROAD-WAY.

Throughout the exhibit the examples of motive power will be shown upon the rails and bed of their period, a remarkable amount of original material having been secured. There are on the way from Europe sections of rail, some antedating the present century, used on European tramroads as early as 1790.

In the collection are four of the original rails, with their chairs, etc., upon which the Liverpool & Manchester locomotive trial of 1829 took place, and as the length of track at that time was scarcely more than half a mile, the value of the rails secured may be imagined. An advance of 600 per cent. was offered for them by people in France. The *Rocket* will stand upon these rails. It is the only existing full-size representation of the famous English engine in its original form, the original *Rocket* so carefully preserved in the South Kensington Museum being the remodeled locomotive, largely changed from what it was when the winner of the Liverpool & Manchester prize.

DRAWINGS.

Besides the models of the early locomotives, another feature of the exhibition will be a series of drawings of locomotives beginning with the earliest examples and experiments, and showing the Sail period, the Horse period, the Manual period, the early Traction Power period, the Tramway period, and the Rack system, giving more than a hundred examples, finishing with modern examples of simple and compound locomotives, the latter constituting a showing remarkably complete, as it will include every compound system known.

Other sections of the gallery will contain series indicating progress in connection with the great locomotive manufacturing companies and firms of this country and of Europe, the interest manifested and the co-operation extended by them being of the heartiest character.

CAR EQUIPMENT.

Nothing pertaining to railroad history has apparently been so neglected as the development of car equipment, both passenger and freight. Books have been written, almost any number of them, upon locomotives, but no author has taken up the history of equipment comprehensively and with a determination to establish the facts. The difficulties in the way have been so numerous, the material so hard to get at, as to deter the attempt. It is now, however, being made.

The co-operation of F. E. Stebbins, long the Chief of the Railroad Car Bureau of the United States Patent Office at Washington, has been obtained, and the work already accomplished presages ultimate and unquestioned success.

The leading car manufacturers in this country and abroad have shown the most encouraging interest. Many have been personally visited and induced to have their records carefully searched; and in the end the showing will be a feature of the gallery. The evolution and development will be indicated in a series of large drawings similar to that already described, the set including probably a hundred examples, among them for the first time representations of the early cars on the Baltimore & Ohio, the company placing upon its line the first eight-wheel cars ever run.

RAILROAD APPLIANCES.

As has been said of equipment, so it may be stated of railroad appliances, the history of the inception and perfection of even the most important of them being anything but connected, and thus lacking value for study and comparison. In this country and all over Europe the responses to requests for co-operation by leading manufacturers have been such as to insure that this branch will be striking in every respect.

THE DEVELOPMENT OF THE BRIDGE.

Theodore Cooper will prepare a series of pen-and-ink drawings showing the development of the American bridge; while Clement E. Stretton will complete drawings showing the development of the European railroad bridge.

Mr. Stretton has been Major Pangborn's representative in Europe for months. He is an Englishman of long experience in railroad life, and his earnest, active work has added inestimably to the value of the exhibit. In a recent letter to Vice-President Lord he says:

"Does it not seem strange that there are all these drawings and photographs to be had, yet there is no collection made over here? The first important and the finest collection of the English engines ever made will be that of your company's at Chicago."

RAILS AND ROAD-BED.

The study of the evolution and development of the rail and bed has been long and exhaustive. The work in this line hitherto accomplished, while good as far as it went, very far from covered the whole; and therefore to perfect the series of upward of a hundred different types, which will be illustrated in wash drawings by C. I. Ward, has required much time and laborious sifting of authorities, representations and data.

The great European railroad companies have heartily cooperated in the exhibit, and their contributions of detail drawings and photographs will excite admiration. No such exquisite mechanical drawings have ever been seen in this country, while the photographs of locomotives are upon a scale of such artistic finish as to astonish the few who have been permitted to view them.

Major Pangborn is collecting a superb series of photographs showing exterior and interior views of the royal trains of the world, and original drawings, lithographs, autograph letters and relics generally. He purposes to show at the least one example of every locomotive company or firm that has existed in this country and in Europe. His effort to show photographic scenes of railroad life, motive power, equipment, stations, bridges and the like in every country where a locomotive whistle has been heard has been successful.

From the above description, which does not exaggerate the general scope, extent and interest of this exhibit, it will be seen that no similar collection has ever been made of historical data, relating to the history of railroad engineering. Its value, however, and to a great extent its interest, will depend upon the authenticity of the objects exhibited. Everything should be sacrificed to this. It is, therefore, to be regretted that the artists who have made the drawings which are to form part of the exhibit were not restrained in the adornment of the otherwise admirable drawings with imaginary landscapes. It shakes our confidence in the veracity of the drawing of an old locomotive when it is represented in the midst of surroundings which it is plain had no existence in fact. The interest and value of the exhibit will be due chiefly to its historical veracity and not to spectacular effect. Whatever is imaginary is not history, and detracts from the real value and interest of an exhibit of this kind, in the preparation of which the Baltimore & Ohio Railroad Company have shown so much liberality.

It will be learned with much gratification by those who are interested in the subject to which the exhibit relates, that a record of it, in a sumptuous volume, with excellent illustrations and an elaborate history of the evolution of railroads, by Major Pangborn, is in preparation. The permanent preservation of the collection after the close of the World's Fair is also contemplated.

The Works of the Robert Poole & Son Company, in Baltimore.

This establishment is located at Woodberry, a suburb of Baltimore, Md., on the Northern Central Railroad, adjoining the northern limit of the celebrated Druid Hill Park. The founder of the company is Mr. Robert Poole, who has now reached a ripe old age, but is still active in the management of the affairs of the company. He commenced business in a small shop in the rear of a carriage house on Holliday Street, in Baltimore, in 1842, and had the misfortune to be burned out the first night after he started. He afterward associated himself with a Scotchman named Ferguson, under the firm name of Poole & Ferguson. They started in business in 1843 in a shop on North Street, and continued until 1851, doing a general jobbing machine business. In 1851 Mr. Poole bought out Mr. Ferguson, and Mr. German H. Hunt became associated with Mr. Poole, and the firm became Poole & Hunt. They carried on the business in the shop on North Street for some years, but finding it too small, they bought the property which is now occupied by the shops at Woodberry, and in 1851 commenced moving their plant gradually from the North Street shop to buildings which had been erected on the new site. The original purpose was to devote the new shops to the building of locomotives, but when they were ready to be occupied the demand for locomotives had fallen off very much, and there was then little inducement to go into that business. The firm, therefore, continued in their old line—that of general machine business—which has been developed in many different directions. Instead of taking up some one or a few specialties the firm adopted the policy of providing an equipment capable of doing any of those kinds of work which are not made specialties by other establishments, their aim being particularly to do very heavy work for which other shops have not the necessary tools and appliances. In the development and application of machinery to so many and varied purposes, there is constantly a great deal of work to be done outside of the usual lines, and which is necessarily of a more or less original character. When such machinery assumes large proportions, as it often does, few shops are prepared to undertake it. During the past few years this company has been providing shops and a plant capable of handling and doing the heaviest class of work. These appliances will be described further on.

As already remarked, the firms in which Mr. Poole was the leading member did a general machine business. This included stationary steam-engines, which formed a considerable portion of the work before and even after the shops were moved to Woodberry, but of late this branch has received less attention than has been given to it by other firms. Among the work which was done in these shops was sugar, oil, paint, saw-mill, mining, hydraulic and fertilizer machinery, steam fire-engines, chilled car-wheels, coal and street cars. Several brass rolling-mills and white-lead works have been equipped, and the plant for a large number of cable roads has been made here. Quite early in its history the firm made a specialty of

the manufacture of the Leffel double turbine water-wheels. Appliances for furnishing steam or water-power had, necessarily, to be supplemented with the means for transmitting and distributing this power. This naturally led the firm to make a specialty of the manufacture of this kind of machinery of the lightest to the heaviest class—particularly the latter. This includes shafting, couplings, pulleys, gearing, hangers, pedestals, etc., which are supplied for flour and grist mills, cotton and woolen mills, paper and rolling mills, fertilizer and other factories, cable and electric railroads, etc.

It has been remarked in these pages before that the best literature on some technical subjects is the trade catalogues of some firms. The Robert Poole & Son Company have contributed their quota to this kind of publications. They have issued a number of descriptive catalogues relating to the different specialties which they manufacture, which, to persons seeking information relating thereto, will be found very interesting. Their pamphlet on turbine wheels is of this kind and is profitable reading to any one seeking information on that subject. The given. The list of finished pulleys includes over 800 different diameters and faces. A great variety of hangers, pedestals, base-plates, brackets, etc., are also enumerated. The company keep a large stock of the ordinary sizes of these appliances on hand, which can, for that reason, be furnished promptly. They have also a large assortment of patterns of wire rope transmission wheels or sheaves, ranging in size from 18 in. to 14 ft. diameter.

The facilities of the company for furnishing gearing are also very good. The plant for the production of machine-molded gearing is very perfect, and will produce cast gearing which is equal in accuracy of pitch to cut gearing. The advantage of cast gearing over that which has teeth cut in a machine is that in making the former hard iron of the strongest kind can be used, whereas if the teeth are cut a softer material, which can be readily worked in a machine, must be used. The list of gearing includes over 3,000 different sizes and varieties of spur gearing up to 16¼ ft. in diameter, and over 3,500 kinds of bevel and miter gearing. In speaking of the latter, attention is

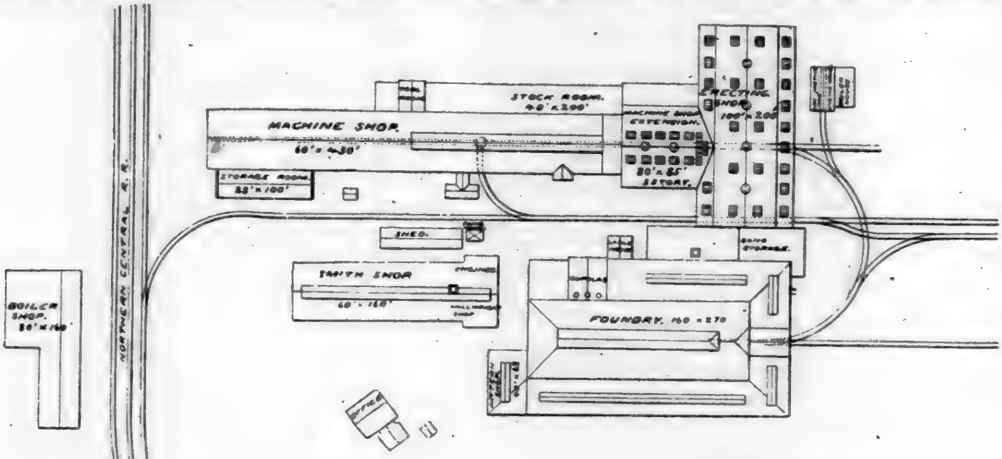


Fig. 1.

PLAN OF WORKS OF THE ROBERT POOLE & SON COMPANY, BALTIMORE.

directions which are given for ordering a wheel, if followed, must lead any one who contemplates doing so to understand the subject much more thoroughly than he would without such specific directions. A diagram showing a section of the wheel, with an explanation of the principles of its action, would be a desirable addition to this pamphlet. The observations about the use of small wheels and their connected machinery is also very suggestive.

The directions in this pamphlet for the measurement of the quantity of water which flows in a stream can be understood by a person of the most ordinary intelligence, and will consequently be of very much greater use than any amount of mathematical gymnastics would be. Some excellent illustrations show very clearly different applications of the wheel. These are followed by a series of tables showing the power, number of revolutions per minute, and also the number of cubic feet of water discharged per minute for each size of wheels under heads of from 3 to 40 ft, which will be found very useful and convenient. Directions for setting the wheels are also given, and further illustrations of various applications of the wheels and methods of arranging the shafting, gearing, bearings and pulleys, on which the success of such motors is often as dependent as upon the wheel itself. Altogether the pamphlet is a very interesting one, and must be especially useful to any one who is either using or contemplating the use of such machinery.

The price-list of shafting, pulleys and hangers which this company has issued will give an idea of the extent of this branch of their business and the facilities which they have for supplying this kind of work. In a table on page 4 a list of pulleys varying from 5 in. to 144 in. in diameter, and from 1 in. to 60 in. face, which includes 101 different diameters, is called in the catalogue to a fact which is not generally understood. "Miter wheels," it is said, "are bevel gears of equal diameters and number of teeth, with their axes at right angles. The same teeth coming in contact at each revolution tend to increase any variations that may occur in pitch, frequently causing noisy and irregular operation, particularly should two of the teeth not be properly lubricated. An odd tooth in one of the gears serves to change the order of the contact of the teeth, so that the same teeth shall not always meet. These are called hunting-tooth gears, and as they avoid the difficulty above named with true miters, are much more desirable to use when it is at all practicable."

Especial attention has been given by this company to the manufacture of what are called spur and bevel mortise wheels. These are cast-iron wheels which have recesses or mortises cast in them to receive wooden cogs or teeth instead of having iron ones. These mesh into wheels with iron teeth. The iron teeth being stronger than wooden ones, the latter are made thicker than the former, the spaces between the iron teeth therefore being considerably wider than they are when both wheels have iron teeth. Wooden teeth are used for gearing which runs at a very high speed, or which must be noiseless, or both, as the elasticity or yielding nature of the wood resists sudden shocks or jars better than a material as unyielding as iron and with less noise. The teeth are made of hickory or maple wood, which is first thoroughly seasoned and then boiled in paraffine, so as to fill the pores and prevent shrinkage. They are accurately fitted into the openings or mortises in the wheel and are held by dovetailed wedges driven in between the teeth behind the face of the wheel. They are then accurately cut to their required form on a special machine for that purpose. Wheels of this kind 16 ft. in diameter have been

made, and the company is prepared to make them of 25 ft. in diameter.

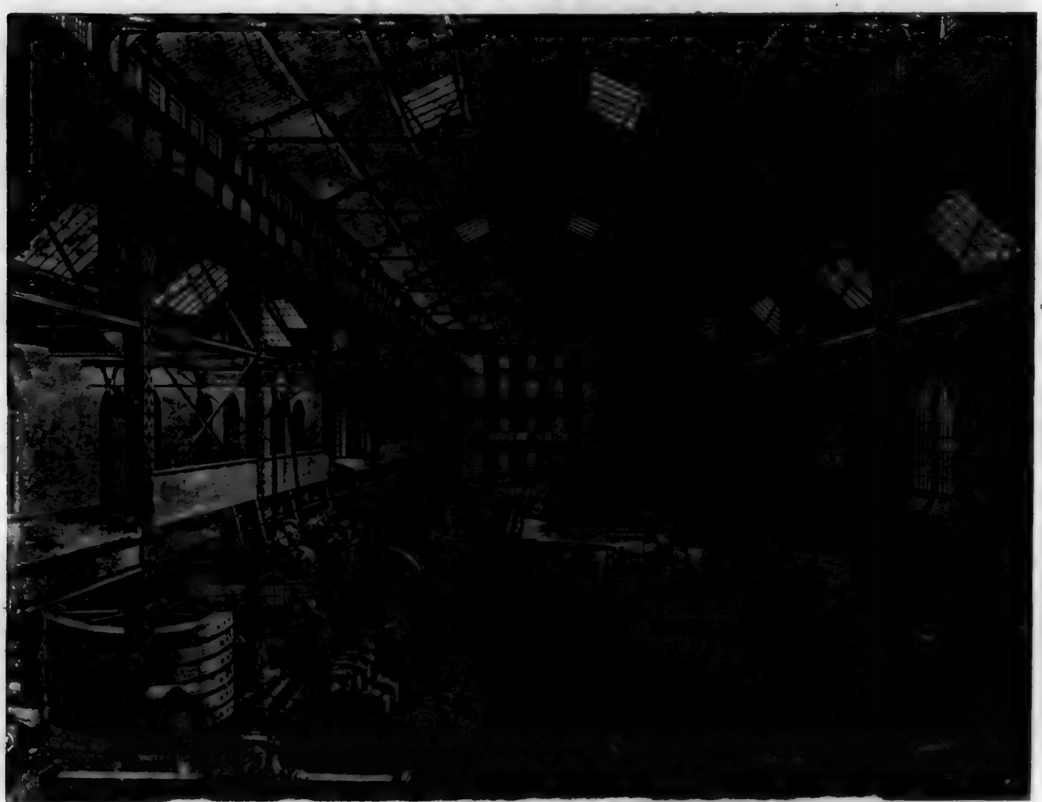
A variety of internal gears, face mortise wheels, screw or worm, and other gears are described in the catalogue.

The teeth of the larger sizes of gears, which are finished, are generally planed on a special machine for that purpose, instead of being cut with a rotary cutter or milling tool. This saves the expense of the latter, as all that the planing machine requires is a template the shape of the teeth, to guide the tool over the surface of each tooth, while it is being planed.

For the successful working of heavy machinery for transmitting power good design is of the utmost importance. What constitutes good design can only be known after extended experience. The machinery of a mill or of a cable railroad must run continually, some of it day and night from one year's end to another. It is therefore of the utmost importance that all should be done that is possible to insure durability and security against accident, and to give the maximum strength to the different parts. There is perhaps no firm or company in the country which has had such an extended and varied experience in the construction of this class of machinery as the one whose works are here described. The utmost care is taken to give ample and effective bearing surface for all shafting and have it properly supported and adjusted to sustain the continued wear to which it is subjected. In these shops journal bearings of all large shafts are babbitted, and after being cast in its place the metal is hammered so as to consolidate it and give it density for resisting wear. The bearings are then bored out accurately to fit the shafts.

The plan, fig. 1, herewith, shows the general arrangement of the shops which are located in a valley adjoining the northern limits of Druid Hill Park, in the village of Woodberry, where several large cotton duck mills are located. The plan shows the dimensions and position of the buildings.

In a business in which machinery of new design forms so large a part there must be ample facilities for pattern making. About 20 men are now employed in this department, in a shop which is well lighted and supplied with every facility of doing work accurately. Among the specialties are three cast-iron surface plates 4 ft. × 8 ft. ribbed underneath and planed on top and finished with a true surface. Large protractors are also engraved on their faces, which are used to lay off angles. The convenience of such plates in squaring and laying off work will be apparent.



ERECTING SHOP OF THE ROBERT POOLE & SON COMPANY, BALTIMORE.

The foundry is provided with excellent facilities for doing the different classes of work which is turned out by this establishment. This is especially true of appliances for casting, gearing, pulleys, etc. For molding gearing a pattern is made of one tooth including two spaces. This is attached to a vertically movable head of a molding machine, and the flask is placed on a table below which can be accurately turned any fraction of a revolution by a graduating mechanism. The pattern is lowered into the flask and one tooth is molded in the sand. The pattern is then withdrawn and the flask is turned a distance equal to the pitch of the teeth; the pattern is again lowered, and another tooth is molded. This process is repeated until the wheel is complete. Within certain limits wheels of any size and number of teeth can thus be molded on these machines, and with an accuracy equal to that of cut teeth.

Besides the ordinary tools found in all machine shops, this company has the following special tools for doing heavy work: A planer 12 × 12 ft., to plane 30 ft. long; eight boring mills running from 5 ft. up to 12 ft. diameter; special machines for cutting iron and wooden gearing and for doing shafting and pulley work. There are also several machines for planing gears of large sizes.

Fig. 2 is an interior view of the new erecting shop, which is 100 × 200 ft. in size, and is built with a view of being extended northward as business requires it. The engraving will give an idea of the height of the building, which is sufficient to give a clear lift of 54 ft. under the hook of the traveling crane, which has a 60-ft. span and a capacity of 30 tons. The crane was built by William Sellers & Company. The structure is arranged for two such cranes whenever they are required.

The noteworthy machine in this building, parts of which are shown on the right side of the engraving, is the large combined pit and chuck lathe, which has a capacity for turning an object 54 ft. in diameter and 12 ft. face. As indicated by its name, a large part of this machine is below the shop floor and out of sight. We expect, however, to give full engravings of it hereafter. It was designed and built by this company in their own shops.

In the front part of the shop, on the same side as the large lathe is located, is a gear cutter for planing the teeth of gears of any size up to 20 ft. in diameter. The cutting mechanism of this machine can be applied to the large lathe and can then cut gears of 50 ft. diameter.

On the right-hand side of the shop, nearly opposite the big lathe, is a boring mill which will take an object 25 ft. in diameter and 10 ft. high. This was also designed in their own establishment, but the upper part, which is in sight, consisting of the cross head, posts, boring bars, etc., was made by Messrs. Bement, Miles & Company, of Philadelphia. The driving gear, which is very heavy, is all below the shop floor and out of sight, and was made by the Robert Poole & Son Company.

At the further end of the shop is a double-headed lathe of 63 in. swing and 85 ft. long. The heads run independently of each other. The lead screws connected to the two heads are arranged in a very ingenious way, so that they can be connected together, forming a continuous screw extending the whole length of the lathe.

A very important part of the business of this company of late years has been the manufacture of the driving plant for cable railroads. Some idea may be formed of the character, or, as our Yankee brethren would say, the "heft" of this kind of machinery, from the following extract, taken from a description of the cable system operated by the Chicago City Railroad Company on the State Street Line, by H. H. Windsor, the plant for which was built at the establishment herein described. In this description it is said:

"The main driving pinions fastened to the crank-shafts are 6 ft. in diameter and 40 in. face, weighing 32,000 lbs. each. These teeth are staggered, and mesh into those of the main driving gears (also staggered teeth) 10 ft. in diameter, fastened to main shaft. These gears weigh 42,000 lbs. each. They are marvels of the molder's skill, running true, and, considering the great power transmitted, comparatively noiseless, although there has been no machine work done on the teeth, they being left just as they came from the sand. The fly-wheels on the engine crank-shafts are from the same firm; they are 24 ft. in diameter, and each weighs 90,000 lbs. The main line shaft is steel, 16 in. in diameter and 68 ft. long. It is in four sections and revolves in eight bearings. There are two pinions on this line shaft, one 5 ft. and one 6 ft. in diameter, 24 in. face, weighing respectively 12,000 and 13,000 lbs.

"Meshing with each driving pinion is a 10-ft. diameter gear, weighing 26,000 lbs. Said gear is fastened to a shaft carrying a drum on each end. A second pair of drums is carried by a shaft having a similar gear, while between the two there is an idler shaft with a 5-ft. diameter pinion. The drums driven by the 6-ft. pinion on the main line shaft drive their cables one mile per hour faster than those driven by the 5-ft. pinion. These shafts are of steel, 14 in. in diameter and 17 ft. long, resting in pillow-blocks 19 in. in length.

"The drum shafts are 14 in. in diameter and 17 ft. long; they run in three pillow-blocks which are bolted to a heavy cast-iron framework, which in turn is anchored to solid concrete foundations 13 ft. deep.

"The incoming cable passes around its pair of drums with two or three wraps, as the case may require; then leads from the bottom of the drum to the tension carriage, where it passes around the tension wheel from the under side, and leads out into the street, passing around a 12-ft. horizontal sheave, and is afterward elevated to its proper level in the channel. The drums, gears, engines and shafting make an aggregate weight of over 1,000,000 lbs., and occupy a space 151 ft. long and 100 ft. wide."

The following is a list of lines whose plant has been built by the Robert Poole & Son Company: Chicago City Railroad Company, Chicago, Ill. (three plants); Third Avenue Railroad Company, New York, N. Y.; North Hudson County Railroad Company, Hoboken, N. J.; Kansas City Cable Railroad Company, Kansas City, Mo. (two plants); Metropolitan Street Railroad Company, Kansas City, Mo.; Grand Avenue Railroad Company, Kansas City, Mo.; People's Cable Railroad Company, Kansas City, Mo.; Cable Tramway Company, Omaha, Neb.; St. Paul City Railroad Company, St. Paul, Minn. (two plants); Holmes Street Railroad Company, Kansas City, Mo.; Denver City Cable Railroad Company, Denver, Col.; Providence Cable Tramway Company, Providence, R. I.; Los Angeles Cable Railroad Company, Los Angeles, Cal.; Washington & Georgetown Railroad Company, Washington, D. C.; Baltimore Traction Company, Baltimore, Md.; New York & Brooklyn Bridge, Brooklyn, N. Y.; Baltimore City Passenger Railroad Company, Baltimore, Md.

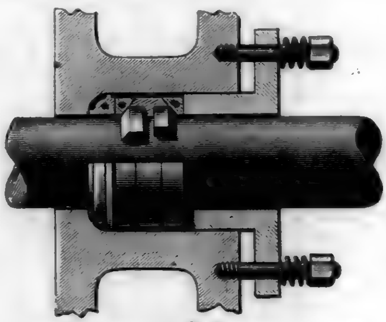
The works herein described are within the city limits of Baltimore, and can be most conveniently reached by the Northern Central Railroad, which passes the entrance to their grounds, and gives them abundant facilities for transportation. As already remarked, the founder of the company, who is still active in its management, is Mr. Robert Poole, who is seconded by his son, Mr. George Poole, under whose management it is safe to predict a continuation of the past success of these works.

Manufactures.

The Forrest Silver-Bronze Packing.

THE accompanying illustration shows a form of packing which has been carefully tested on the rods of stationary, locomotive and marine engines for some two years past, with excellent results. It is claimed for it that it is self-adjusting; not easily deranged; keeps tight by perfect contact instead of excessive pressure; does not bind or crowd the rod; bears lightly and uniformly. It can be applied to any ordinary stuffing-box without change.

As shown in the cut, the packing forms a valve at the bottom of the stuffing-box, preventing steam or water from escaping around the outside, and closes around the rod, preventing leakage from the inside. The whole packing is held on the rod and kept seated by the gland; the springs on the studs outside maintain a uniform pressure and follow up the wear automatically.



THE FORREST SILVER-BRONZE PACKING.

The first brass ring in the bottom of the stuffing-box is the seat-ring; it is put in independently, neatly fitted to the bottom and walls of the stuffing-box and grooved out on the bottom to hold the Usudurian gasket, in which it is imbedded to make it tight.

The next brass ring is ground on to the seat-ring, thus making a tight valve-joint. This ring is made from $\frac{1}{8}$ in. to $\frac{1}{4}$ in. smaller in diameter than the stuffing-box, to admit of lateral motion without touching the walls of the stuffing-box. The rest of the packing, as shown, is of the same outside diameter, and free to move in accordance with the vibrations of the rods.

The outside ring next to the gland is the same shape as the bottom ring (valve-ring), but does not require to be tight at the gland. This ring slides on the gland laterally in the same manner as the valve-ring slides on the seat-ring, to accommodate the vibrations of the rod.

The two inner rings next to the rod are made of silver bronze and take all the wear, and when these rings are worn out they can be renewed, making the packing as good as new without providing any other new parts, as all the rest lasts indefinitely.

The two silver bronze rings are held against the rod by a case made of soft yellow metal.

The case and bronze rings are each put in in two pieces, placed so as to break joints, are provided with suitable dowels to prevent registering, and may be put in and taken out in less time than any other packing.

The seat, valve and cap-rings are screwed together around

LOCOMOTIVE RETURNS FOR THE MONTH OF OCTOBER, 1892.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Av. Train. Passenger Cars.	Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Cost per Locomotive Mile. Repairs	Fuel	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Cost per Car Mile. Passenger.	Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Alabama Great Southern	...	53	39,290	80,688	34,300	134 277	2,911	....	...	63.90	97.50	36.04	76.63	...	...	4.70	4.50	0.30	0.40	6 30	2.00	18.30	....	...	...
Alabama & Vicksburg	....	17	17,871	15,948	10,380	44,199	2,600	....	....	47.73	89.29	47.38	62.69	...	...	6.50	5.30	0.39	0 70	6.10	1.80	20.50	....	...	....
Atchison, Topeka & Santa Fé	834	737	.... ..	....	417,271	2,391,912	3,246	....	....	...	....	...	87.52	....	...	4.59	7.86	0 28	0.14	6.96	1.49	21.02	....	...	1.58
Canadian Pacific	603	...	480,320	963,498	471,995	1,915,813	3,177	...	....	....	....	...	65.19	...	...	3.33	10.93	0.39	....	5 38	1.18	21.10	...	1.72	3 33
Chic., Burlington & Quincy	524	....	....	....	....	2,023,815	3 862	5.24	19.42	....	....	...	84.26	...	...	3.78	5 65	0 22	0.19	6.58	...	16.42	....	...	1.35
Chic., Milwaukee & St. Paul	811	....	.... ..	....	....	2,909,962	3,588	....	....	....	....	....	70.40	...	...	3 41	7.36	0.27	..	6.78	....	17.84	....	...	2.05
Chic., Rock Island & Pacific	563	..	575,937	1,098,537	438,173	2,102,647	3,802	....	....	....	....	....	64.60	....	...	2.66	6.11	0.28	....	6.06	0.39	15.45	....	...	...
Chicago & Northwestern	885	....	702,318	1,544,303	838,579	3,085,100	3,486	....	...	....	....	....	88.75	....	...	3.11	7.51	0.35	....	6.34	0.77	16.08	....	....	1.77
Cincinnati Southern	....	99	80,471	171,137	81,413	333,021	3,364	....	...	56 86	116.96	41.32	85.11	..	...	3.90	4 60	0.28	0.00	6.50	1.70	17.00	..	....	....
Cumberland & Penn.*	22	22	6,030	38,603	....	44,633	2,029	....	...	...	....	...	83.64	....	...	3.10	4.37	0.42	....	...	1.76	9.76	....	...	...
Delaware, Lackawanna & W. Main L.	208	193	....	....	....	751,375	3 893	....	....	...	....	....	88.54	....	...	2.78	6.44	0.40	...	5.80	...	15.42	....	...	....
Morris & Essex Division	159	....	170,445	232,922	13,661	416,028	2,617	....	...	....	....	....	67.50	....	...	3.73	10.53	0.40	...	6 58	...	21.17	....	...	3.08
Hannibal & St. Joseph	....	67	73,054	185,809	40,694	299,557	4,537	5.55	17.08	...	...	....	81.50	11.74	6.39	3 38	5.90	0.18	0.20	6.50	...	16.11	....	...	1.46
Kansas City, F. S. & Memphis	147	....	103,991	262,055	132,936	497,982	3,387	....	...	...	....	....	60.51	....	...	3.01	4.99	0.31	0.32	7.34	....	15.97	....	....	1.61
Kan. City, Mem. & Birm	41	39	37,169	65,341	14,714	117,224	3,006	....	...	...	....	....	65.18	....	...	3 01	3.69	0 23	0.43	7.05	....	14.41	....	....	1.09
Kan. City, St. Jo. & Council Bluffs	....	44	59,060	47,700	50,039	156,79	3,733	5.00	22.04	...	...	....	65.08	13.98	4.21	3.90	5.87	0.14	0.12	6 02	....	16.05	....	....	1.89
Lake Shore & Mich Southern	590	....	437,508	866,901	656,283	1,960,692	3,323	....	...	60.22	84.93	35.37	63.29	....	....	2.87	4.78	13	0.05	6.95	0.19	14.97	....	..	1.51
Louisville & Nashville	...	1347	496,363	631,544	416,813	1,684,718	3,669	5.15	16.28	64.54	100.63	46.26	81.64	12.64	6.50	3.93	6.52	0.26	0.53	6.11	1.55	18.90	3.19	1.41	1.60
Manhattan Elevated	..	298	778,965	....	53,483	832,448	2,891	....	...	...	....	...	42.28	....	....	2.90	8.40	0.30	....	8.80	....	19.70	....	....	3.96
Mexican Central‡	146	118	....	....	....	381,176	[illegible],230	....	...	...	...	...	69.25	....	....	3 95	15.57	0.47	.19	5.45	0.86	26.49	...	....	5.60
Mil., L. S. & Western	112	....	78,388	159,616	100,618	338,622	[illegible],023	....	...	...	...	...	73 41	....	....	3.41	9.93	0.37	...	6.17	0.94	20.42	...	....	2.75
Minn., St. P. & Sault Ste. Marie	....	....	65,081	161,225	65,988	292,294		4.45	20.52	...	....	...	67.12	....	....	3.09	11.39	0.21	....	6 42	....	21.11	...	1.59	3.39
Missouri Pacific	349	314	....	.... . .	....	1,230,[illegible]	3,919	4.47	17.68	...	....	...	89.09	15.08	6.37	4.78	6.45	0.35	1.18	6.54	1.41	20 71	4.14	1.37	1.44
Mobile & Ohio	107	80	75,103	150,531	62,756	288,390	3,228	....	20.80	....	....	...	61.83	....	....	2.60	4.37	0.20	0 61	5.85	0.94	14.57	....	....	1.43
N. O. & Northeastern	....	33	27,783	57,884	31,619	117,286	3 554	....	....	63.49	103.04	37.11	76.04	....	....	5.10	6.50	0.38	0.60	6.40	1.50	20.50	....	...	....
N. Y., Lake Erie & Western	..	621	403,259	986,756	296,885	1,745,400	2,811	4 60	23 00	87.90	133.10	68.40	....	13.90	5.80	4.44	7.64	0.39	1.86	7.24	1.11	23.70	....	1.60	1.30
N. Y., Pennsylvania & Ohio	....	253	138,363	432,337	150,765	741,465	2,931	5.30	18.50	73.10	114 70	73.20	...	13.50	6.20	3.88	5.66	0.30	2.73	6.76	1.08	20 33	....	1.66	1 15
Norfolk & Western, Gen. East. Div.*	....	143	104,341	283,202	56,361	443,904	3.148	4.80	19.40	....	...	....	102.56	....	...	5.96	3.10	0.70	....	...	....	9.70	...	....	....
General Western Division*	....	122	65,154	250,667	29,494	345,315	2,830	4.70	15.20	...	...	...	122.70	...	...	11.90	3.70	0 70	....	....	....	16.30	...	....	....
Ohio & Mississippi	117	....	141,770	146,969	95,649	384,388	3,285	...	...	...	....	...	60.46	....	...	3.36	2.48	0.21	1.14	5.41	1.36	13.91	...	....	0 88
Old Colony	....	230	346,866	131,405	133,314	611,48	2,659	....	...	....	....	...	68.95	....	...	3.19	11.59	0.63	....	6.66	0.79	22.88	...	...	3.75
Philadelphia & Reading	...	....	484,494	808,389	622,637	1,915,520	....	...	...	...	...	....	78.18	...	....	4.44	4.89	0.31	....	5.97	0.39	16.00	....	....	....
Southern Pacific, Pacific System	721	....	.. ....	.. ....	....	1,740,198	2.414	....	...	...	...	....	70.42	....	....	5.02	17.71	0.41	2 27	7.29	1.19	33.89	...	....	5.11
Union Pacific	991	....	708,939	1,513,606	407,462	2,714,187	2,739	5.77	18.12	....	...	....	93.55	13.51	6.60	7.62	8.69	0.40	0 81	7.95	1.04	26 51	4.46	1.77	1.57
Vicksburg, S. & P.	....	14	10,680	10,608	9,780	31,068	2,219	....	....	56.50	[illegible]	36.[illegible]	61.54	....	....	6.90	6.90	0.24	1.40	6.80	3.00	25.20	....	...	....
Wabash	406	357	418,442	799,885	372,261	1,585,588	4,199	5.10	18.02	60.33	104.96	55.[illegible]	84.00	13.81	5.88	3.28	4.71	0.29	...	6.39	0.77	15.39	2.64	0.97	1.12
Wisconsin Central	149	131	180,282	236,060	91,393	507,735	3,876	....	....	....	....	....	88.17	....	....	2.95	9.66	0.27	....	7.00	....	19.93	....	....	2.32

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Wages of engineers and firemen not included in cost.

† Number of engines in revenue service only; average mileage is also based on revenue service.

‡ The Mexican Central Railroad reports 18.70 units of work per $1 of expense; 159.00 units of work per ton of coal; 12.58 lbs. of coal per unit of work. The unit of work is 100 gross tons hauled one mile in one hour on a straight and level track.

the rod, and never have to be disturbed to renew the packing.

This packing is made by the Forrest Silver-Bronze Packing Company, of No. 115 Liberty Street, New York, from whom further information can be obtained.

The Smith Water-Tube Boiler.

THE two illustrations given show the Smith safety boiler, one of the class known as water-tube or tubulous boilers,

Fig. 1.

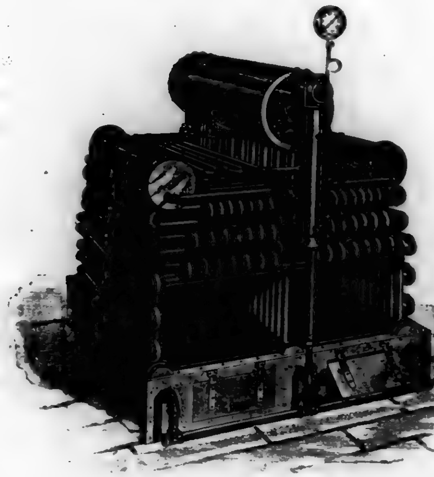


Fig. 2.

THE SMITH WATER-TUBE BOILER.

which are now coming into very general use where high steam pressures are used. Fig. 1 shows the boiler complete with steel casing; fig. 2 has the casing removed, showing the arrangement of the tubes and also the grates. The general design and arrangement, the points in which it differs from other boilers of the same class, can readily be seen from fig. 2.

The manufacturers of this boiler claim for it the following advantages:

1. Freedom and equal circulation of the water throughout every pipe in the boiler; when the boiler is emptied by opening the blow-off cock not a particle of water remains in it.

2. The steam-generating pipes are so arranged that there is no chance for soot or ashes to lodge or accumulate on or between the pipes, there being square openings left up through the entire mass of pipes for the heat and gases to circulate through, the same in effect as in ordinary tubular boilers.

3. The horizontal fire-box pipes are so arranged and suppoted by the three (or if so desired, four) vertical pipes that it is impossible for them to sag or drop down even if, through carelessness, they became overheated or red hot. The fire-box is also surrounded at the sides and back of the boiler with a double row of steam-generating pipes, so that the fire has very little effect on the asbestos-lined boiler jacket, and, therefore, very little heat is lost or transmitted to the boiler-room.

4. The feed-water pipes, feed-water heaters and receivers are located on top of the steam-generating pipes, so that the waste heat which will not generate steam may be taken up and utilized in heating the feed water. The feed-water drums are located at the right point, so that they also act as feed-water receivers, or reservoirs, which carry the greatest amount of water just at the point where the water should be kept in the boiler, so that the water will not fluctuate rapidly should the pump or injector not be regulated accurately.

These boilers are made in sections or sizes from 20 to 200 H.P. The Huyett & Smith Manufacturing Company, of Detroit, Mich., are the makers.

General Notes.

THE Dunkirk Engineering Company, Dunkirk, N. Y., recently completed a planer of unusual size for Struthers, Wells & Company, of Warren, O. This tool can plane work 20 ft. in length.

THE Grant Locomotive Works, Chicago, are building 25 heavy 10-wheel locomotives for the Chicago, Burlington & Quincy Railroad.

THE Schenectady Locomotive Works, Schenectady, N. Y., are building nine 12-wheel locomotives with 22 × 26-in. cylinders and 54-in. drivers for the Duluth & Iron Range Railroad.

IT is announced by Messrs. Burnham, Williams & Company, of the Baldwin Locomotive Works, that from January 1. 1893, Messrs. Robert Spencer and Carter H. FitzHugh will act as their representatives for the Northwest, with offices at 1013 Monadnock Building, Chicago.

IN order to provide means for largely increasing its manufacturing facilities and production, the Lunkenheimer Brass Manufacturing Company, of Cincinnati, has been reorganized as the Lunkenheimer Company, with $500,000 capital. The officers are: Edmund H. Lunken, President; C. F. Lunkenheimer, Vice President and Treasurer; D. T. Williams, Secretary.

THE Ensign Manufacturing Company, Huntington, W. Va., has on hand orders for 325 gondola cars for the Cleveland, Akron & Columbus; 250 box cars and 750 hopper-bottom gondola cars for the Chesapeake & Ohio Railroad.

THE Carlisle Manufacturing Company on December 22 moved into and formally opened its new shops at Carlisle, Pa., a number of guests being present on this occasion. The new shop consists of main building 304 × 100 ft., with wings for the shipping department and boiler-room. The power is furnished by a Corliss engine of 150 H.P. The new shop is fully equipped with tools and is very conveniently arranged for handling the work.

THE Baldwin Locomotive Works in Philadelphia turned out 670 locomotives in 1892. Of that number, 210 were compound engines of the Vauclain type.

THE Automatic Electric Signal Company has been organized in Indianapolis to make and introduce a system of signaling between trains devised by Mr. B. C. Seaton, of Nashville, Tenn. In this system the inventor uses a light third rail laid between the two ordinary rails. Under each locomotive is a contact wheel running on the center rail; the latter is broken into short open circuits, so that the approach of trains, either from different directions or the same direction, will close the circuit, and in doing so cause a bell to ring on each engine as a danger signal.

THE Baldwin Locomotive Works are to build 20 consolidation engines of the Vauclain compound type for the Norfolk & Western Railroad. They will have cylinders 14 and 26 × 24 in. and 56-in. driving-wheels.

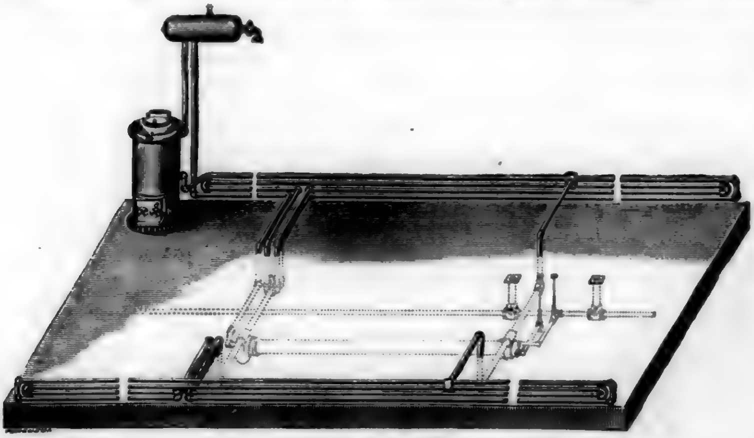


Fig. 1.

Fig. 2.

Fig. 3.

MULTIPLE CIRCUIT HOT-WATER SYSTEM.

THE Rhode Island Locomotive Works in Providence are to build 12 heavy passenger engines for the Boston & Albany Railroad. Six of these engines are to be of the ten-wheel type, with six drivers coupled.

THE National Car Spring Company, of New York, and the Oswego Railway Spring Company have been consolidated. The new organization will be known as the National Railway Spring Company, and its officers are: Theodore Irwin, President; Thomas M. Bell, Vice President; George B. Sloan, Jr., Secretary and Treasurer; Edward A. Cliff, Superintendent. The factories at Newark, N. J., and Oswego, N. Y., will be continued for the present, but the company purposes building an extensive plant in Buffalo, N. Y., as soon as possible.

THE St. Charles Car Company, St. Charles, Mo., are building for the Missouri Pacific Railroad four 60-ft. postal cars with six-wheel trucks, finished in accordance with the standard postal regulations; 10 chair cars very handsomely finished, having large double windows, smoking and wash-rooms and provided with the latest pattern of Scarritt reclining chairs; 20 first-class passenger cars, 55 ft. long, with smoking-rooms, and fitted with Scarritt-Forney high-backed seats. All these cars are handsomely finished; they have the Safety Car Heating and Lighting Company's steam heating system and are lighted with gas on the Pintsch system.

THE New York Safety Car Heating & Lighting Company has just completed a plant at Council Bluffs, Ia., and is ready to supply gas to any companies desiring it. It has a capacity of 20,000 ft. per day. The company's Kansas City plant will be in operation in a few days. It is also building plants at Toledo, at Buffalo and at Chattanooga, Tenn. There is besides a plant under construction at Portland, Ore., and one at Oakland, Cal. These will all be in operation inside of three or four months.

THE Union Pacific Railroad is equipping all its cars with the Safety Company's systems of heating and lighting as fast as the cars under o repairs at the shops; so also is the Missouri Pacific.

THE Philadelphia office of the Pittsburgh Testing Laboratory of Hunt & Clapp has been discontinued, and all business will be done hereafter at the headquarters in Pittsburgh.

THE Hon. T. H. Anderson, United States Minister to Bolivia, says, in a recent letter to the Department of State, that the industry of working wood by machinery is a growing one in South America, and the trade for all classes of wood-working machinery is given to the United States. And he further says that the Egan Company, of Cincinnati, O., controls over 50 per cent of this trade in this class of goods, simply as the result of enterprise in successfully placing superior goods before the South American buyers.

THE firm of Booth, Garrett & Blair, Analytical Chemists, in Philadelphia, have established a department in their laboratory for the mechanical testing and inspection of iron, steel and other metals. The class of work that they propose to undertake will include not only rails, structural and bridge material, but also railroad equipment and supplies, water-pipe, and all similar material subject to specifications and tests, chemical or physical. To carry out this plan they have associated with them as a partner, Mr. F. H. Lewis, known as an expert in this specialty, who will have general charge of the department. They are also adding to the physical laboratory a modern high-speed testing machine of 100,000 lbs. capacity.

THE National Hollow Brake-Beam Company, of Chicago, has leased its entire business, plant and patents to the Chicago Railway Equipment Company, which company from January 1 manufactures and sells the national hollow brake-beams, and assumes the business heretofore carried on by the Brake-Beam Company. The office of the Chicago Railway Equipment Company is at 40th and Hopkins Streets, Chicago. Mr. H. S. Burkhardt is President and E. B. Leigh, General Manager. Messrs. A. J. Farley and L. C. Burgess will be in charge of the sales in the West, with office No. 514 Phœnix Building, Chicago, and Mr. F. G. Ely in the East, with office at No. 29 Broadway, New York, as heretofore. Mr. H. B. Robischung is Superintendent of the works.

THE Manhattan Equipment Company, recently organized in New York by Mr. H. M. Warren and associates, has purchased the business of the firm of Reginald Canning & Company, and will conduct it hereafter. Mr. Thomas B. Inness will manage the equipment department of the business, making a specialty of second-hand cars and locomotives.

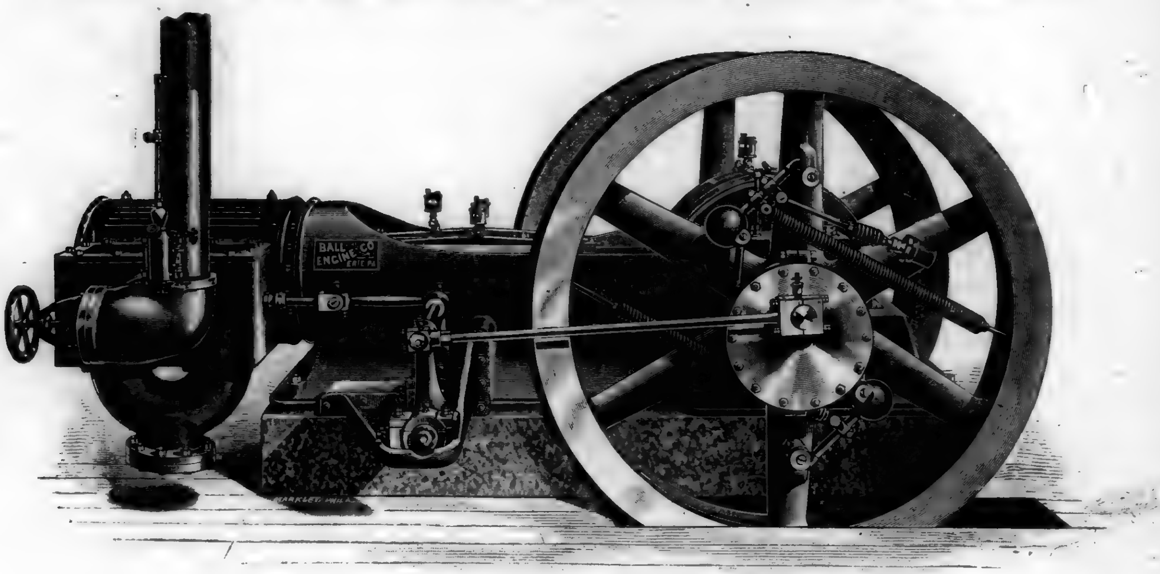
THE W. & A. Fletcher Company, New York, has ordered 1,840 tubes of the Servé ribbed pattern for the 10 boilers for the new steamer building for the Fall River Line. The boilers are of the Scotch type, 14 ft. in diameter and 14 ft. 6 in. long, and each will have 184 of the Servé tubes, 3½ in. in diameter and 10 ft. 3½ in. long. These tubes have made a very good showing in service.

Multiple Circuit Hot-Water System.

A NEW hot-water circulating system recently patented and put into service by the Consolidated Car Heating Company is known as the multiple circuit system.

The multiple circuit is a drum system which meets the demand for a sufficient heating surface for the largest cars. The steam pressure required is 4 lbs. There is no practical limit to the amount of heating surface which may be provided, the heating pipes being divided into eight or more different circuits, which are connected to the same source of heat. All parts of the car receive the heat from the different circuits simultaneously and in the same degree.

The circuit is through the two upper pipes to both ends of the car and returning to the center through the two lower pipes, where the water enters through a 2-in. pipe the return end of the heating drum. The construction of the drum is shown in figs. 2 and 3, which show four 1¼-in. corrugated copper pipes attached to the cast-iron head before the drum is put together.



NEW ELECTRIC RAILROAD ENGINE.

The body of the drum, shown in fig. 3, is a wrought-iron pipe 5 in. in diameter, the pipe connections being made through the cast-iron heads which enclose the end of the drum. There are two ports in one of the heads. Through the upper one the steam is supplied to the interior of the corrugated pipes within the drum; the lower port is for removing the water of condensation. The four pipes of corrugated copper have a total length of 85 ft. and are arranged in two separate steam circuits. The water of all circuits flows the entire length of the drum. Steam from the train-pipe is admitted into the corrugated pipe, and the water is heated by contact with the external surface of this pipe. The drum beneath the car is placed against the needle beam. Fig. 1 shows the general arrangement of the piping and drum in this system.

An Engine for Electric Work.

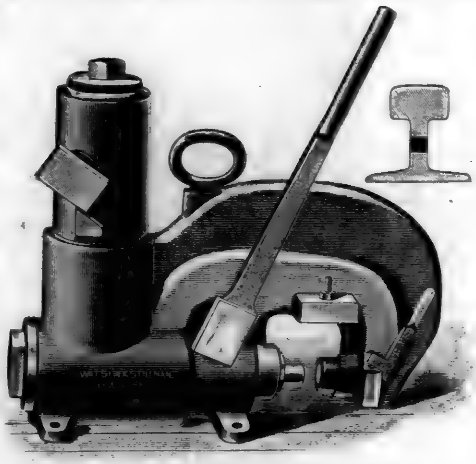
The illustration herewith shows a new engine designed for the severe work required on electric railroads, for electric welding, etc., by the Ball Engine Company, of Erie, Pa. It is intended to meet the requirements of heavy duty, varying loads and long continuous runs, and seems well adapted for service of this kind.

The frame of the engine is massive and heavy and internally ribbed, so as to give the greatest attainable stiffness. The crank-shaft is forged out of a solid steel ingot of the best quality, and is of large diameter and great strength. The connecting rod and straps are forged out of steel ingots and are of a new design, combining strength with efficiency. The main bearings are unusually large, and are so arranged that both the vertical and side wear of the liners may be taken up. The main bearing liners are genuine babbitt, carefully scraped and fitted, and as they are made removable, they can be quickly and easily taken out and replaced with new ones if necessary. The crank-pin boxes are lined with genuine babbitt. The cross-head boxes are made of pure copper and tin. The cross-head is a steel casting with very large bearing surfaces, and is babbitted on the four faces with genuine babbitt. The cross-head pin is tool steel, and the piston-rod a fine quality of crucible steel. The oiling devices are of the most improved form, and all fittings are complete and of the best description. The regulation by means of the improved governor is such that the engine has shown in practice excellent regulation under conditions where the variation in load on the generator from zero to the full capacity has occurred in less than five seconds of time.

It may be added that great care is taken in building these engines to secure good workmanship in all the details.

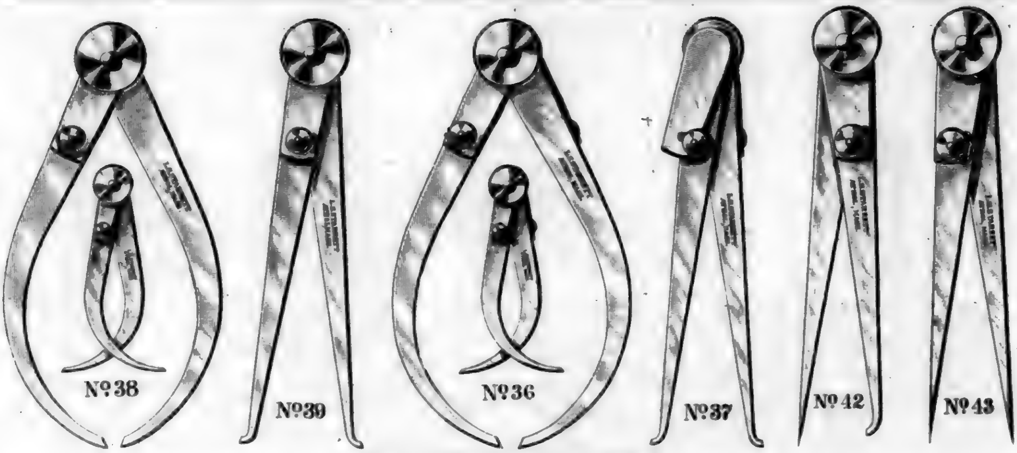
Some Hydraulic Rail Punches.

The accompanying cut shows a hydraulic punch for making the bolt holes in the web of an ordinary rail. The makers claim that these punches are the first made which can be conveniently used by an ordinary gang of men, and which do not require to have the rail removed from the road-bed in order to punch it.



HYDRAULIC PUNCH FOR WEB OF RAIL.

By the use of the quick-acting lever, shown in the middle of



SOME HANDY FORMS OF CALIPERS.

he cut, the ram may be worked in and out a distance of 2 in. without the loss of time and labor of pumping. In mounting the die in a sliding bolster, which latches it in position, an additional opening is obtained without the extra weight which would be necessary to get a 4-in. movement, and also a reservoir of sufficient capacity. A guide is placed at the top of the jaw which, once set for any pattern of rail, will cause all holes to be punched at the same height. In returning the punch to the cylinder the pumping socket must be brought down against the head lug before the quick-working lever can be used.

These punches are made in two sizes, for 70-lbs. and 90-lbs. rails. The makers are the well known firm of Watson & Stillman, of New York.

The second illustration shows a tool by the same makers,

HYDRAULIC PUNCH FOR SPIKE-SLOT OF RAIL.

which is an adaptation of their improved hydraulic punch, for the purpose of punching the spike-slots in the base of heavy rails for regular railroad service, as is frequently required on switches and curves; it is the first tool of the kind which is convenient, expeditious and reliable, making a clean-cut slot. The body of the punch is somewhat longer than in the regular style of punch, and is cut out in front to bring the center of the punch to the proper position. As in the improved hydraulic punch, this punch may be brought down to the work without the labor of pumping, being both raised and lowered by the lower lever shown in the illustration. They are very carefully designed to avoid the troubles which formerly existed in the punches of this character. The head is of the same construction and size as in the corresponding sizes of the regular make of punch. No. 2, with $1\frac{1}{4}$-in. jaw, weighing about 90 lbs., has sufficient power to punch the $\frac{11}{16} \times \frac{11}{16}$ slot in the side of the base of a 90-lbs. steel rail. Guides are placed on the side for determining the depth, and also act as strippers.

Some Handy Tools.

The illustrations given show a series of exceedingly handy tools of new patterns, devised and made by Mr. L. S. Starrett, of Athol, Mass., who is well known as a maker of machinists' tools.

Nos. 38 and 39 show outside and inside calipers, called by the maker lock-joint calipers. They are of wide scope for both inside and outside work, can be instantly adjusted to their full extent, and as quickly locked firm in the joint, and are yet provided with a sensitive adjustment. They are made to supersede the old style firm joint, also the lock joint with split-leg adjustment. The improvement consists, first, in a socket joint made tapering, and locked or released by a partial turn of the knurled disk drawing it together. A spring washer under the disk maintains an easy friction in the joint when unlocked. In the under side of the short arm is a slot containing a stiff spring. Riveted into the middle leg and projecting through an opening in the arm is a *threaded stud* on which is a knurled nut having a beveled hub—this bears against a cone in the arm; the action of the spring holding them together turning the nut, presses them apart and adjusts the leg while the joint is locked. The spring taking up all back-lash, the legs are firm.

These calipers are made in sizes from 4 in. to 24 in.

Nos. 36 and 37 show the lock-joint transfer calipers. They are an improvement on the preceding patterns, as in addition to the ordinary use they may be employed to take measurements inside of chambered cavities, over flanges, etc., and may be removed and replaced without losing the size calipered. This is done by loosening the nut, binding one arm to the auxiliary leaf and swinging it out or in (while the joint is locked) to clear the obstruction, then moving it back against a stop, where it will show the exact size measured.

Like those first described, these calipers are made in sizes from 4 in to 24 in.

No. 42 shows a very handy pair of hermaphrodite calipers with lock-joint and sensitive adjustment. These are made in 6 in., 8-in. and 10-in. sizes.

No. 43 shows a pair of dividers with the Starrett lock-joint attachment and sensitive adjustment. They are light and stiff, with large capacity, instantly opened, closed and locked. The points are nicely tempered. They are made in 6-in. and 8-in. sizes.

The report going the rounds a few weeks back in regard to the Baltimore & Ohio making a heavy increase in the freight equipment seems to have had its origin in the fertile brain of a newspaper reporter; but it is understood there will be some new cars contracted for in the near future, the exact number not being yet decided on. The policy of the company is to improve its equipment by rebuilding the old, short cars, and make them standard length, using the old materials.

PERSONALS.

FREDERICK H. LEWIS has resigned his position as Manager at Philadelphia for the Pittsburgh Testing Laboratory, and has taken an interest with Messrs. Booth, Garrett & Blair, of Philadelphia, in a department of mechanical testing and inspection.

CHIEF ENGINEER NATHAN H. TOWNE, U. S. N., for some time past Chief Assistant in the Bureau of Steam Engineering, has been granted leave of absence for two years. During that time it is understood that he will act as Consulting Engineer at the Cramp Yards in Philadelphia.

JAMES MACBETH has been appointed Master Car-builder in charge of the Buffalo shops of the New York Central & Hudson River Railroad. He was formerly in charge of the locomotive shops at Buffalo, but more recently has been Superintendent of Motive Power of the Adirondack & St. Lawrence Railroad.

EUGENE CHAMBERLAIN has resigned his position as Master Car-Builder of the New York Central & Hudson River Railroad to undertake the management of the Lancaster Malleable Iron Works as a partner. He has been connected with the New York Central for 18 years and for eight years has had charge of the Buffalo shops.

CHRISTOPHER BENSON, who is 86 years old, and is now an inmate of the Philadelphia Hospital at Blockley, can claim to be one of the first locomotive engineers in the country. He was employed on the old Mohawk & Hudson Railroad in 1829, and ran the old *John Bull* and the *De Witt Clinton* on that road. He was for many years on the New York Central, but advancing age forced him to give up work several years ago.

COMMODORE FOLGER's retirement from the position of Chief of the Bureau of Ordnance, Navy Department, leaves a vacancy which has been filled by the appointment of CAPTAIN WILLIAM T. SAMPSON, for some time past at the Washington Navy Yard. CAPTAIN JOHN A. HOWELL is made commandant of the Washington Yard, and COMMANDER T. F. JEWELL Superintendent of the Gun Factory. COMMANDER GEORGE A. CONVERSE succeeds Commander Jewell in charge of the Torpedo Station.

JOHN FRITZ, Chief Engineer and General Superintendent of the Bethlehem Iron Works, relinquished the duties of Superintendent at the close of the old year. He has been succeeded in that position by OWEN LEIBERT, who has been for many years one of his assistants. Hereafter Mr. Fritz will act as Consulting Engineer of the works. Mr. Fritz built the Bethlehem Works from the first blast furnace to their present splendid proportions. He was appointed the Superintendent of the works on June 20, 1860, coming to Bethlehem from Johnstown, where he had been Superintendent of the Cambria Iron Works. Other important changes in the staff of the Bethlehem works occurred at the close of 1892. RUSSELL W. DAVENPORT, the Assistant Superintendent, becomes Second Vice-President of the company. ROBERT H. SAYRE, JR., assumes the position of Assistant Superintendent. ALBERT LADD COLBY, Head Chemist, will hereafter be Superintendent of the blast furnaces.

OBITUARIES.

HORACE SMITH, who died in Springfield, Mass., January 15, aged 83 years, was born in Cheshire, Conn., and received his mechanical training in the United States Armory at Springfield, Mass. He made some important improvements in the machinery used there, and later, in connection with D. B. Wesson, invented the Winchester rifle and the Smith & Wesson revolver, both of which are well known. He retired from business a number of years ago with a moderate fortune, and has since lived quietly in Springfield.

EDWARD H. MARTIN, who died in Cleveland, O., December 29, was born in England in 1832. He received a liberal education, gaining the degree of civil engineer, and he engaged in many large manufacturing enterprises in his native land. In 1868 he came to this country, and the following year acted as Assistant Engineer in superintending the construction of the bridge over the Ohio River at Louisville. In 1870 he supervised the construction of the Reese Agricultural Works at Mansfield, in that year inventing one of the first automatic horse-rakes ever manufactured. In 1872 he removed to Cleveland and built the Union Steel Screw Works, holding the position of Constructing Engineer. In 1874 he entered the employ of the Cleveland Rolling Mill Company, remaining there until 1891. While with that company he designed all the machinery that was put up in the works, including boilers, engines, pumps and all varieties of work. He invented an improved pumping engine which, under the name of the Martin pump, became known everywhere. In 1891 Mr. Martin entered the service of the Baackes Wire Nail Company, remaining there until his death. During this period he built the Baackes rod mill.

H. STANLEY GOODWIN, who died in Bethlehem, Pa., December 25, aged 60 years, was born in Morris, Conn. He began his railroad service in 1852 as a rodman on the Delaware, Lackawanna & Western, and was Chief Assistant Engineer of that road from June, 1853, until March, 1857. For a year after that he was Principal Assistant Engineer of the Honduras Interoceanic Railroad. From November, 1858, to June, 1860, he was Resident Engineer of the Western Division of the Pittsburgh, Fort Wayne & Chicago. During the early years of the War he was Superintendent of the Catawissa Railroad, and from April, 1863, to April, 1866, he was Chief Engineer of the Northern Central. He then moved to Bethlehem, and from April, 1866, to December, 1882, was General Eastern Superintendent of the Lehigh Valley. For the last ten years he has been General Superintendent of that road, and when it was leased by the Philadelphia & Reading, President McLeod recognized his value and appointed him General Eastern Superintendent of the Philadelphia & Reading. He was affectionately regarded by the railroad men under his charge and by his townspeople. He was an instructor in civil engineering at Lehigh University in 1868 and 1869, under Dr. Coppee's administration as President.

GEORGE FRICK, the founder of the Frick Company, of Waynesboro, Pa., died in his home at that place on Friday, December 23. His wife and four sons survive him. He was born in Lancaster County, Pa., on November 25, 1826, and was 66 years of age. He was a son of Alvam and Catherine (Diffenbaugh) Frick, natives of Lancaster County and of German descent. He was the fourth of a family of six children, was raised on a farm, and, like thousands of other American boys, received his education in the common schools. When he was eleven years of age his father removed to Franklin County, Pa., where he grew up on the farm. He learned the trade of a millwright, and followed the business for a few years. When quite a young man he conducted a repair shop at Quincy, and built grain drills or seeding machines. In 1850, after his marriage, he removed to a farm near Ringgold, where he erected a shop and began building the Frick engine, which he invented. Shortly after he rented another shop and added to his business the building of the Geiser threshing machine, which has had a great reputation through all that region of country. He and Peter Geiser then became associated together, and the result has been the creation of two large establishments in Waynesboro—one, the Frick Company, for the manufacture of steam-engines of various kinds and sizes, ice-making and refrigerating machines, saw-mills, etc.; the other, the Geiser Manufacturing Company, which is making agricultural machinery. In the early fifties Peter Geiser, a farmer's boy, scarcely out of his teens, perfected and tested his threshing machine and separator. Mr. Frick was then operating his shop near Ringgold, and come most serviceably to his young friend and collaborator's assistance in furnishing him with the castings for his machine. Thus the two industries sprang from the same period, the same location, and have since continued an association and development along equal lines of struggle and triumph. They are to-day the twin factories of which Waynesboro is justly proud.

In the year 1858 Mr. Frick, finding the scope of his market quite outgrowing his facilities, and induced by appeals from certain of his fellow-citizens, concluded the purchase of a piece of land now the site, in part, of the present Geiser works. In the following year he erected a large frame shop and foundry, together with a residence, hard by. In 1850 he moved his plant from Ringgold in and began the operation of his new and larger works. This same year Mr. Frick made an arrangement with Peter Geiser, who had been receiving overtures from Greencastle parties to locate his works there, to manufacture his threshers at the new works. This arrangement was the beginning of a movement which finally resulted in the concentration of the various branches of the Geiser separator works—eight in number at that time—in Waynesboro.

Mr. Frick conducted this enterprise with yearly increasing success till 1866, when the separator branch of the business passed into the hands of the firm of Geiser, Price & Company, who purchased the works. Mr. Frick, this same year, pur-

chased a parcel of land just across the street, where he erected the large and well-planned brick shops now occupied by the American Manufacturing Company. Here he continued to conduct the business of engine building till 1873, when the partnership of Frick & Company was formed, to whom he sold his interest in the works. He remained with the enterprise in the capacity of Superintendent till 1888, when from declining health and vigor he was compelled to resign. Since that time, with the exception of a year's connection with the American Manufacturing Company, for whom he invented their valuable simoon evaporator, he has led a life of well-earned retirement and rest.

In the October (1892) number of this JOURNAL an elaborate description of the present works of the Frick Company was published. These now rank among the first of their kind in the country.

The *Keystone Gazette*, a local Waynesboro paper, to which we are indebted for most of the particulars of Mr. Frick's life, said of him that "his life was a busy one, and his nature, though gentle as that of a child, was of heroic mold. Otherwise he could not have struggled up from comparative obscurity through all the adversities and discouragements that beset effort, especially upon new lines, to the parentage and headship of one of the largest and most flourishing industrial establishments of the land. Nature had endowed him with the spark of inventive genius, but the flame that finally lit his pathway with honor and renown was the result of work, persistent application, determination to succeed, trial, drudgery and sacrifice. In this school of discipline his faculties were sharpened, and when in the zenith of his career his executive ability and capacity for grasping complicated details were of the highest order."

PROCEEDINGS OF SOCIETIES.

American Society of Civil Engineers.—At the meeting of December 21 Mr. U. H. Broughton read a long paper on the Shone Hydro-Pneumatic Sewerage System, describing various applications of this system. This paper was briefly discussed by members present.

AT the regular meeting, January 4, a paper by A. J. Grover, on Flood Waves in Sewers and their Automatic Measurement, was read and discussed.

Mr. E. B. Dorsey described the Harbor Improvements at Tampico, Mexico, as now in progress.

The following elections were announced:

Members: John W. Alvord, Chicago; James Francis, Lowell, Mass.; Alfred Rosenzweig, City of Mexico; Henry G. Ruttan, Winnipeg, Manitoba.

Associate Members: S. B. Miller, Hoboken, N. J.; Kennerley Bryan, Chicago.

THE officers elected at the annual meeting for 1893 are: President, William Metcalf; Vice-Presidents, Charles Macdonald and E. L. Corthell; Directors, Foster Crowell, Henry G. Prout, Willard S. Pope, F. P. Stearns, J. T. Fanning and O. S. Landreth; Secretary, Francis Collingwood; Treasurer, John Bogart.

American Forestry Association.—The annual meeting was held at the Department of Agriculture, Washington, D. C., December 20. Mr. B. E. Fernow, Chairman of the Executive Committee, presented his report, in which it was stated that there are at present six reservations of forest, representing a total of 3,252,260 acres. These are as follows: White River, Pike's Peak and Plum Creek, Colorado; Pecos and Canadian River, New Mexico; Bull Run, Oregon; and Yellowstone National Park timberland reserve, lying south and east of Yellowstone Park, Wyoming. A public State park was proclaimed last August at Lake Itaska, Minn., headwaters of the Mississippi River. There are 26 proposed forest reservations now being considered which are situated in California, Colorado, Idaho, Minnesota, Montana, New Mexico, North Dakota, Oregon, Washington and Wyoming.

There was an animated discussion on the merits of the Paddock bill, now on the Senate calendar, which proposes to place the control of the timber lands in the hands of the Secretary of Agriculture, who will be given administrative action in order to protect and utilize the timber. The proposed reservations are not land desired for agricultural purposes.

The following officers were elected for the ensuing year: President, Hon. Sterling J. Morton, Arbor Lodge, Neb; Treasurer, Henry M. Fisher, Philadelphia, Pa.; Secretary, Dr. N. H. Egleston, Department of Agriculture, Washington, D. C.; Corresponding Secretary, J. D. W. French, Boston, Mass.; Chairman of Executive Committee, B. E. Fernow, Chief of the Forestry Division, U. S. Department of Agriculture, Washington.

Master Car Builders' Association.—The Committee on Attachment of M. C. B. Couplers to Cars has issued circulars requesting manufacturers of M. C. B. type couplers and of draft devices for cars to submit detail drawings or blue prints of their couplers or other devices to the Committee, accompanying them with full descriptions. These should be sent to the Chairman, Mr. E. D. Bronner, whose address is "Care Michigan Central Railroad, Detroit, Mich."

American Society of Naval Engineers.—The officers elected at the recent annual meeting in Washington are: President, Chief Engineer H. Webster; Secretary and Treasurer, Passed Assistant Engineer W. M. McFarland; Members of Council, Assistant Engineer W. W. White, Passed Assistant Engineers F. H. Bailey and J. N. Hollis.

Civil Engineers' Society of St. Paul.—At the annual meeting in St. Paul, January 9, resolutions of thanks for courtesies received on the recent excursion to West Superior and Duluth were adopted.

The following officers were elected: President, George L. Wilson; Vice-President, J. D. Estabrook; Secretary, C. L. Annan; Treasurer, A. O. Powell; Librarian, A. Münster; Representative on the Board of Managers of the Association of Engineering Societies C. J. A. Morris.

The President made the following appointments: Examining Board, C. F. Loweth, A. O. Powell and E. E. Woodman; Auditor, W. C. Merryman.

Mr. J. J. Sewall gave a description of the Marshall Avenue Bridge over the Mississippi; and Mr. W. H. Wood spoke of his Experience on the Mexican Southern Line.

Engineers' Club of Cincinnati.—The fifth annual meeting was held December 15, with 31 members present. The reports of the Secretary and Treasurer were presented, showing the Club to be in a satisfactory condition. The following officers were elected to serve during the coming fiscal year: President, Colonel Latham Anderson; Vice-President, W. B. Ruggles; Directors, M. D. Burke, Charles A. Ewing and H. L. Hoeffer; Secretary and Treasurer, J. F. Wilson.

The retiring President chose for the theme of his annual address, Ethics of Engineering, which he treated very thoroughly and understandingly. His paper was ordered printed for distribution. The customary annual lunch was served.

Western Society of Engineers.—At the annual meeting, in Chicago, January 4, the following officers were elected for the ensuing year: President, Robert W. Hunt; Vice-Presidents, H. A. Rust and H. B. Herr; Secretary and Librarian, John W. Weston; Treasurer, F. G. Nourse; Trustee, George S. Morison.

Northwest Railroad Club.—At the annual meeting in St. Paul, January 10, the following officers were elected: President, William McIntosh; Vice Presidents, John Hickey and E. A. Williams; Secretary, W. D. Crossman; Treasurer, H. L. Preston.

Southern & Southwestern Railroad Club.—At the last meeting, in Atlanta, Mr P. W. Gentry described the system used on the Richmond & Danville Railroad for regulating the consumption of oil on locomotives.

The following officers were elected: President, Pulaski Leeds; Vice-Presidents, James Meehan and A. W. Gibbs; Treasurer, A. G. Steinbrenner; Secretary, S. A. Charpiot.

Master Mechanics' Association.—Secretary Angus Sinclair issued the following circular under date of December 27, 1892:

ANNUAL CONVENTION.

The Twenty-seventh Annual Convention of the American Railway Master Mechanics' Association for 1893 will be held at Lakewood, N. Y., with headquarters at the Kent House, commencing Monday, June 19, 1893.

There are two hotels close together, and the proprietor of the Kent House will receive all applications for rooms and locate the guests. His address is John C. Brady, Kent House, Lakewood, on Chautauqua Lake, N. Y.

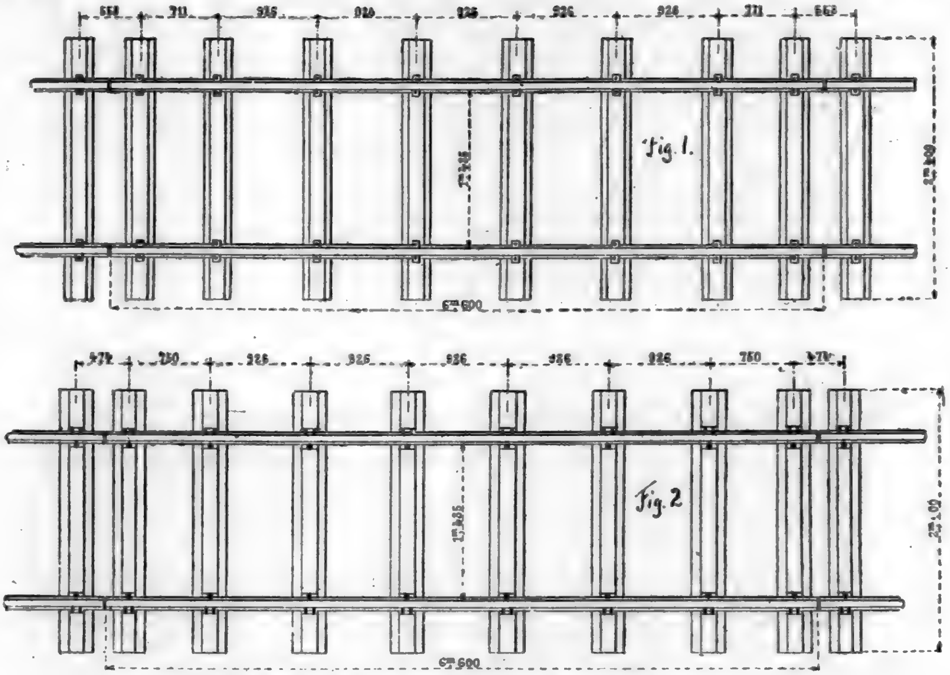
The hotels agree to a uniform rate of $3 per day, when nothing extra is wanted.

Messrs. R. C. Blackall, T. A. Bissell and Angus Sinclair are a Committee of Arrangements for this Convention.

NOTES AND NEWS.

Austrian Ties and Track.—The illustration herewith shows two sections of track on the Emperor Ferdinand Northern Railroad of Austria, that given in fig. 1 being laid on Bessemer steel ties of the Heindl pattern, and that in fig. 2 on oak ties treated by the chlorate of zinc process. The rails weigh 71 lbs. to the yard. The engravings show the spacing of ties, arrangement of joints, etc., the figures given being in meters.

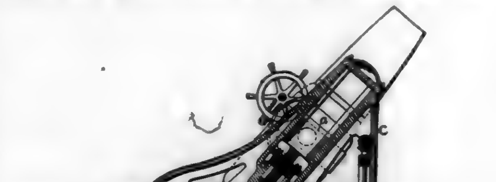
Some account of a test of the steel ties was given in our January number. The Heindl metallic tie is now used for all renewals on this road.



PLANS OF TRACK, EMPEROR FERDINAND NORTHERN RAILROAD.

The Morgan Mortar Mounting.—The accompanying illustration shows a mount for mortars, designed by Mr. William H. Morgan, of the Morgan Engineering Works, Alliance, O., which is intended to be especially an improvement on those mountings having hydraulic cylinders so arranged that the recoil of the gun forces fluid contained in the cylinders carried by the carriage down into a cylinder below the carriage, whereby the carriage is elevated and the energy of the recoil stored for elevating the gun. As water is practically incompressible, it will not yield to pressure when properly housed, and hence may prove too rigid and unyielding under the first shock of the recoil. The object of the new design is to provide means adapted to yield under the first shock of the recoil and before the weights begin to move.

The carriage *A* normally rests on a flange of the ring *B* and is provided with castings *C*, having inclined sideways in which the boxes *a*, carrying the trunnions of the gun, move. The boxes are connected to the upper ends of plungers, *D*, which move in hydraulic cylinders *D'*, carried by the carriage. These cylinders are connected by pipes with a cylinder, *E*, located below the carriage, and the water or other fluid, as it is acted upon by the movement of the plungers caused by the recoil of the gun, is forced from the cylinders on the carriage into the cylinder under the carriage, and there, acting on a plunger, *F*, operates to elevate the carriage. Now, by opening communication between the lower cylinder and the upper cylinders the weight of the carriage will expel the liquid from the lower cylinder and force it into the upper cylinders, thereby permitting the carriage to descend to its normal position and elevating the gun to its firing position. In the drawing the plunger *F* is shown mounted on a block, *G*, seated in the base plate and supported on a series of springs, *H*. The upper end of the plunger rests in the cylinder *E*, and hence it follows that the fluid as it first enters the cylinder *E* will act on the springs and compress them, thus allowing time for the weight (carriage and gun) to begin to move. The plunger is in effect a spring plunger, one end being yieldingly supported and the other end adapted to receive the impact of the fluid forced into the lower cylinder from the upper cylinder. This fluid is under powerful pressure, and as soon as the upper plungers carrying the gun begin to move under the recoil the water in the upper cylinders and in the pipes between the upper and lower cylinders is put in motion, and as the fluid in the lower cylinder is under the same pressure as the fluid in the upper cylinders, it follows that the instant fluid is displaced in the upper cylin-



THE MORGAN MORTAR MOUNTING.

ders an increased space in the lower cylinder must be provided for such displaced fluid. By means of springs yieldingly supporting the plunger the latter is permitted to descend and thus provide space for the fluid forced into the cylinder. This takes the shock off the carriage, and the latter is thus given time to recover and begin to ascend gradually in comparison to what its movements would be were the plunger rigid.—*Iron Age.*

Transmission of Power by Electricity.—In Italy, where there are numerous small water powers, the Italian Electrical Society is making many applications of electric transmission. From the Gravellone waterfall near Padua 200 H.P. are carried half a mile; the Alzano waterfall is used to distribute 180 H.P. at one third of a mile, 40 H.P. at half a mile and 50 H.P. at three miles. A plant is now under construction to transmit 1,000 H.P. from the Cassagno falls to Intra, a distance of six miles.

A Large Gas-holder.—San Francisco has a claim for modesty in respect to various works carried out here in a quiet manner, that would call for much more noise and ink in other places. The gas company, for example, have erected, on the north side of the city, a gas-tank of unusual dimensions that very few people have heard of. It is to hold 2,000,000 cub. ft., is 168 ft. in diameter, and the total height 145 ft. The excavations are 37 ft. deep. The floor coating is 24 in. thick, of stone and concrete. The walls are 8 ft. thick. The iron work was done by the Union Iron Works, and the material furnished here, mainly by the Pacific Rolling Mills Company. The cost of the whole is about $250,000. This is, except some gas-holders at New York and one in Chicago, the largest in this country, and goes to show the fact that electric lighting does not interfere greatly with the consumption of gas.—*Industry, San Francisco.*

A New Sound Steamer.—The construction of the new passenger steamboat for the Fall River Line is now fairly begun at the Roach shipyards, in Chester, Pa., and the vessel promises to be one of the finest specimens of marine architecture and building thus far produced.

The new boat is to be larger, of greater carrying capacity as regards both passengers and freight, and will be even more elaborately finished and furnished than the *Puritan* of the same line, although the *Puritan* now stands first of all vessels of her class afloat. The principal points of difference between the boat now building and the *Puritan* are: the new boat will be at least 20 ft. longer than the last-named; she will have double inclined compound engines, instead of compound beam engines; she will have boilers of the Scotch instead of the Redfield type and her dining saloon will be on the main deck.

The dimensions and proportions of the new steamboat will be as follows: Length over all, 440 ft.; length on water-line, 424 ft.; beam, outside plate, 52½ ft.; width over guards, 93 ft.; depth of hold at lowest point of sheer, 20½ ft.; depth of hold amidships, 21½ ft.; draft of water, 12½ ft.; displacement, 4,550 tons.

The machinery, as indicated above, will be a double inclined compound engine, in general arrangement like that of the *Plymouth*, of the Fall River Line. There will be two high-pressure cylinders, each 51 in. in diameter; and two low-pressure cylinders, each 95 in. in diameter, all having a stroke of piston of 11 ft.

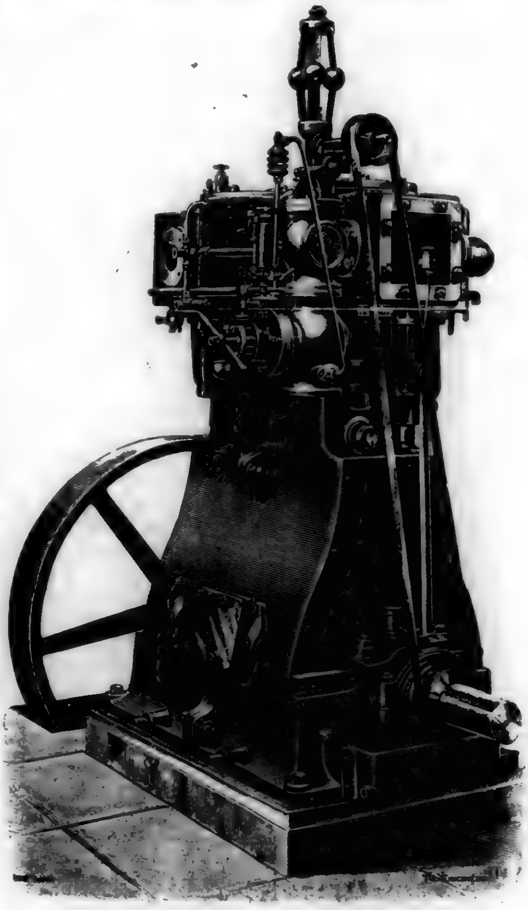
The wheels will be of the feathering type, 35 ft. in diameter and 14 ft. face.

A Subterranean River System.—It has long been known that a subterranean river existed in the Aveyron, near Rodez, in France. At Veyssiere there exists a remarkable natural well some 200 ft. in depth which gives access to the stream. Some time ago two French savants, MM. Martel and Gaupillat, took up their residence in the neighborhood for the purpose of investigating these phenomena. They now report that the natural well of Veyssiere gives access to a subterranean river of considerable size, which flows in a general north-northwest direction. Its course has been definitely traced and determined for two-thirds of a mile. Observations made after the heavy rains of September, 1892, showed that the flow of this river increased suddenly to a very considerable extent, showing that it receives and collects the rain water falling on the plateau above.

The celebrated cascades of Salles-la-Source, near Tindoul, are evidently fed by this subterranean river. Starting from that point the explorers succeeded in ascending the stream underground for nearly 1,000 ft. They then discovered the existence of a great basin serving as a reservoir for the cascades or springs of Salles—which never dry up and vary in flow very little—and spreading out in time of floods into other galleries or caverns which serve to hold the overflow. These caves form an underground storage reservoir of a very curious nature; no other similar one has been explored, though some are supposed to exist in our own country.

An English Vertical High-Speed Engine.—The illustration given, from the London *Engineer*, shows a type of vertical high-speed engine adopted by Robey & Company, of Lincoln, who are extensive builders of stationary engines. It is of interest as showing a pattern popular in that country, as it does not differ materially from those of other builders.

These engines are principally used for electric lighting, although some of them have been very successfully applied for working high-speed shafting direct for saw-mills and other industries. The engine shown is one of the small sizes, and has a high-pressure cylinder 8½ in. diameter, low-pressure 14½ in. diameter by 10 in. stroke, and runs easily and quietly up to 300 revolutions per minute, developing at that speed up to 75 H.P. The larger sizes are made with automatic gear and bal-



AN ENGLISH VERTICAL HIGH-SPEED ENGINE.

anced piston valves. It will be seen all the working parts are enclosed, and the connecting-rod big end runs in a shallow bath of oil; the moving parts are by this means perfectly lubricated. The bearings are exceptionally large, and all the working parts have great strength and ample surfaces. While not competing in economy with long-stroke trip-gear engines, yet these engines are nevertheless worked with a very small consumption of steam, and are constructed for very long continuous runs, and they are frequently combined on one bed-plate with a dynamo, to which they are coupled direct.

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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MR. FREDERICK HOBART is no longer connected with this paper as Associate Editor nor in any other capacity.

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EDITORIAL NOTES.

THE Coupler Bill, which has passed the Senate, a full text which we give in another column, contains one feature which seems to have been almost an oversight. Authority is given to the American Railroad Association to fix the standard height of the draw-bar and also to decide what variations above and below this standard will be allowable. And there is nothing to prevent them from taking the height of the draw-bar of the highest car empty as the upper limit and that of the lowest car loaded as the lowest, which would leave matters just as they are and perhaps a little worse.

IT is a curious commentary on the slowness of apprehension of the City Fathers of some of our near-by cities to note that, whereas there was a tremendous opposition to the elevation of the tracks of the Pennsylvania Railroad in Jersey City, on the ground of inconvenience and damage to property, now the improvement has been recognized as being such a decided success that there is a very serious talk of compelling all of the other railroads entering the city to do the same thing. It would certainly be greatly to the advantage of all the parties interested, both in the railroad properties and the adjoining real estate, if this were done, but the problem of raising the money would be a very serious one for some of the roads to face.

IN an article published in another column there is an interesting statement of the amount of work which is now being done in the ship-building yards along the Great Lakes. The industry certainly seems to be in a very flourishing condition, and all of the yards are busy to their full capacity, which argues well for the development of the transportation facilities and interests between the northwest and the sea coast. And these will undoubtedly receive still further impetus if Congress makes an appropriation for the formation and maintenance of a deep-water channel between the headwaters of Lake Superior and the Hudson River.

GAUGE OF WHEELS AND RAILS.

ON another page we give a condensation of a very excellent paper on Wheel Flanges, which was read before the Western Railway Club by G. W. Rhodes, Superintendent of Motive Power of the Chicago, Burlington & Quincy Railroad, on January 17, 1893. The main purpose of that paper was to show the importance of having a maximum gauge for the thickness of the flanges of car-wheels, as well as a minimum one, which has already been adopted by the Car-Builders' Association.

The subject of wheel gauges and wheel flanges has often been discussed before that Association, and action of various kinds has been taken with reference thereto. To obviate the danger resulting from running wheels whose distance between the backs of their flanges is less than that over the guard-rails and wing-rails at frogs, a standard distance of 4 ft. 5 in. over those rails was adopted in 1882, and of 4 ft. 5¼ in. between the backs of the flanges of the wheels was adopted in 1883. In 1885 the latter was modified so as to allow of a variation of ⅛ in. each way, making the maximum distance between flanges 4 ft. 5⅜ in. and the minimum 4 ft. 5⅛ in.

The difference in the forms and thickness of flanges was often so great, however, that in many cases, if the standard distance between their backs was maintained, the distance between the outside of the flanges, where they come in contact with the rails, was greater than the distance apart of the latter. The importance of having a standard form and sizes for the flanges of wheels thus became apparent, and in 1886 such a standard was adopted, which is now generally known and used.

In the inspection of cars it became important, too, to be able to determine definitely when a flange was worn sufficiently to be condemned. To meet this requirement, the Car-Builders' Association adopted a minimum gauge for the thickness of flanges, and when they are worn enough as to enter this gauge, they are condemned. The necessity for a maximum gauge never seems to have occurred to any one until Mr. Rhodes pointed it out.

There are, however, many complications which have a bearing on the important matter of wheel and track gauges. In order to point these out "so as to be understanded of all men," the subject will be discussed here in a somewhat elementary way. The most serious and important incongruence relating to this subject is the fact that the gauge

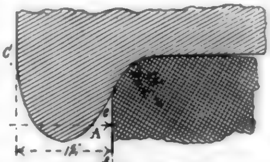
of the tracks of the Pennsylvania system of railroads is 4 ft. 9 in., while that of nearly all the other roads in the country is 4 ft. 8½ in. In any system of gauging wheels this paramount fact must always be kept in mind and provided for.

Then, too, the form of the rail heads has an important bearing on their relation to the wheels, and is the cause of much confusion and what may be called indeterminateness. In Mr. Rhodes's paper he says:

"The Master Car-Builders' standard, as shown in fig. 7 (in his paper), is usually estimated as measuring 1¼ in. through the flange (some would call it 1⅜ in.); with the same method of reckoning, the thick flange measures a strong 1⅝ in. (some would say 1½ in.)."

It will thus be seen that if it be assumed that the maximum dimension named by Mr. Rhodes represents the thickness of the Master Car-Builders' standard flange, it will, apparently, make a difference of ¼ in. in the gauge of the wheels, compared with what it would be if the minimum dimensions were taken as the thickness. The fact is that the thickness which should be taken in computing the gauge, or what may be called the working thickness, is influenced very much by the form of the rail-head. Thus fig. 1 (herewith) represents a section of the Master Car-Builders' flange, in contact with a rail-head, the corner of which is rounded with a radius of ⅝ in. The gauge of the rails would be measured on the line *A*, *e f* being the gauge-line. It will be seen that the back, *C*, of the flange projects 1¼ in. from the gauge-line, and practically represents the thickness of the flange. In fig. 2 the corner of the rail-head is rounded with a curve having a radius of ¼ in. The back of the flange then projects $1\frac{7}{16}$ in. inside of the rail-head, and this dimension represents the thickness of the flange if used on rails of this form.

Fig. 1.



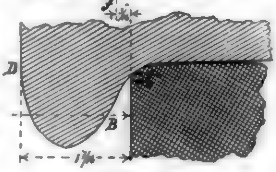


Fig. 2.

In some cases the gauging of the rails also has an important influence on the gauge of the wheels. In fig. 3 the section shaded in full lines represents a form of rail-head introduced about 10 years ago quite extensively, but which has since been modified somewhat in its shape. It is introduced here merely to illustrate what we are trying to explain. It will be seen that the sides of this rail-head have considerable outward slope or inclination. Modifications of this form of rail-head are extensively used, but there is no common agreement with reference to the point from which the gauge is measured. In some cases it is measured on a line *A*, where the side of the head joins the curve of the corner, and in others it is measured at *B*, the widest part of the head. In the one case the practical thickness of the flange is 1¼ in.; in the other, $1\frac{5}{32}$ in. Let it be supposed that the rail is made of the form shown by the area *C*, fig. 2, which is shaded with dotted lines, and that the dotted outline represents a Master Car-Builders' standard flange in contact with such a rail. The practical working thickness of the flange would be as in fig. 2, $1\frac{7}{16}$ in., as shown at *e f*. If compared with a flange in contact with a rail of the form represented by the full lines, and gauged from *B*, there will be a difference of ¼ in. in the practical working thicknesses of the flange.

This may be illustrated in another way. Supposing that a pair of wheels were gauged in accordance with the Master Car-Builders' maximum standard—that is, with a distance of 4 ft. 5⅜ in. between the backs of the flanges. If, now, we add to this twice the working thickness of the flange shown in fig. 2, and we will have $4' - 5\frac{3}{8}'' + 1\frac{7}{16}'' + 1\frac{7}{16}'' = 4' - 8\frac{1}{4}''$. With a gauge of 4 ft. 8½ in. the wheels will, therefore, have a total of only ¼ in. end play or ⅛ in. on each side.

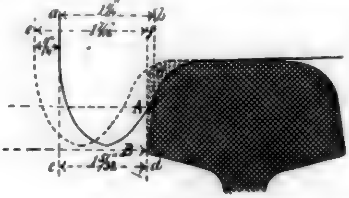


Fig. 3.

If we take a pair of wheels with flanges with a working thickness of $1\frac{5}{32}$ in., as represented at *cd*, in fig. 3, and rails of the form shown by the full lines in this figure, and gauged 4 ft. 9 in. at the point *B*, and assume that the wheels are gauged to the minimum Master Car-Builders' standard distance—4 ft. 5¼ in.—between the backs of their flanges, and we will have $4' - 5\frac{1}{4} + 1\frac{5}{32}'' + 1\frac{5}{32}'' = 4' - 7\frac{9}{16}''$, so that in a 4 ft. 9 in. gauge, with rails like that shown in fig. 3, such a pair of wheels would have $1\frac{7}{16}$ in. total end play. It will thus be seen that wheels may conform entirely to the Master Car-Builders' standard, and yet on some lines of railroad have only ¼ in. total end play, while on others they will have nearly or quite 1½ in. This difference is due entirely to the forms and methods of gauging rails.

Nor is this all that may be said. As long ago as 1877 Mr. Samuel J. Hayes, then Superintendent of Machinery on the Illinois Central Railroad, took a pair of car-wheels and turned off the inside or backs of the flanges, so as to have true surfaces. The wheels were then put under an eight-wheeled car. Quoting from a report made at the ~~time~~, it was said:

"Six measurements were then taken between the flanges at the top and at a similar point at the bottom of the wheels, under different conditions. In some cases, after the measurements were taken, the car was pushed along the track until the wheels had made half a revolution. The second measurement did not differ from the first. The record of experiments given below represents the difference of the distance between the flanges at the top of the wheel and at the bottom. All possible care was taken to have the measurements correct:

"With weight of truck only,	$\frac{1}{64}$ in. full
" " " car body only,	$\frac{3}{64}$ " "
" load of 10,000 lbs., all in one end over wheels measured,	$\frac{6}{64}$ " "
" " of 20,000 lbs., evenly distributed in car,	$\frac{7}{64}$ " "
" " of 25,750 lbs., evenly distributed	$\frac{8}{64}$ " "
" " " 36,000 " " "	$\frac{9}{64}$ " "

"As the experiments were made with the loads at rest, it is evident that under the violent concussion to which an axle is subjected in use, the spring or deflection must be very much greater than that given above."

The axle was of smaller size than is now ordinarily used—the journal was 3¾ in. diameter, the wheel-seat 4½ in. and the middle of the axle $3\frac{11}{16}$ in., but the loads also were only about one-half what are now hauled.

It would be an interesting contribution to our information on this subject if some one would devise an apparatus which would show the spring of axles while the cars are running. This would not be very difficult to do, and would throw much needed light on this important subject; but Mr. Hayes's experiments alone show that the distance between the backs of flanges and their outside gauge is materially effected by the spring of the axles.

The deduction from Mr. Rhodes's paper and a consideration of the subject are:

1. The importance of establishing a maximum gauge for the thickness of wheel flanges.

2. The necessity for a standard form for the heads of rails and for the method of gauging them.

3. The great desirability of having a common gauge for rails on all our roads; or, in other words, the abandonment of the 4 ft. 9 in. or the 4 ft. 8½ in. gauge, or both. Probably an assimilation of these two gauges can only be brought about by a compromise. It is suggested that if the standard gauge of the country was made 4 ft. 8¾ in., it would not be difficult for the roads with either 4 ft. 8½ in. or 4 ft. 9 in. gauges to conform to it. If the American Railway Association should agree that all rails on straight-line track should thereafter be laid to 4 ft. 8¾ in. gauge, the desired result would speedily be reached. As Congress has just legislated on the subject of couplers and brakes, they may, in the near future, see proper to exercise their authority to secure a uniform gauge of track for the whole country.

All or nearly all cars must now run on both the gauges, so that there could be no difficulty in running on a gauge intermediate between the two.

There will probably be more difficulty in securing the adoption of a standard form for the heads of rails than there will be in assimilating the gauges. There seems to be something about the occupation of a civil engineer which prevents him from assenting, conforming or agreeing to any common action or acting in compliance with the views of other people. The reason for this seems to be that in the performance of his duties he generally acts alone. Usually he does not work in accordance with or for the object of suiting other people's ideas. He usually works to please himself alone. He does not make goods to sell to others, and therefore he is not obliged to act in compliance with their views and wishes. The selling of goods cultivates flexibility of character as nothing else will. At the time the Master Car-Builders' Association was considering the question of the gauge and the form for the flanges of wheels, a general invitation was sent out to those in charge of the permanent way of roads to attend the meetings and take part in the discussion. One solitary individual responded to the invitation. Owing to the characteristic of civil engineers which has been pointed out, and to the fact that there is no association through which they can act efficiently, there does not seem to be any hope that a standard form for rail-heads will be adopted unless the American Railway Association should take up the subject and act on it. It is to be hoped that this will be done at an early date.

TRIALS OF THE "VESUVIUS."

The daily papers have been giving more or less obscure reports of the tests of the dynamite gun on board the *Vesuvius*, which have been carried on at Port Royal, S. C. From these reports it might be inferred that the gun and the vessel have been doing about everything that could be expected of them excepting the one thing for which they were especially intended—that is, firing shells loaded with dynamite. On February 2 we were told that the tests of the gun were not continued because "the work done on Tuesday and Wednesday did not quite agree with what had been accomplished in the days previously devoted to ranging the guns. The questions arising relate to the advisability of beginning the firing with the vessel under way without further stationary practice. As there are still about a dozen *unloaded* projectiles remaining in the firing room and projectile racks of the *Vesuvius*, it is probable that they will be fired to-morrow from the vessel in her present position—that is, moored alongside the wharf."

"Captain Rapieff, of the Russian Service, who represents the Dynamite Gun Company, is expected to arrive to-morrow with the fuses and primers required to perfect the mechanism of the loaded projectiles. It is proposed to fire a number of shells, or, rather, aerial torpedoes, *with about 10 lbs. of gunpowder* in their magazines. This will be done to test the action of fuses before using them with the more powerful explosives."

On February 5 we are informed that the fuses have arrived; but as the inventor has not yet secured a patent for them, "it is difficult to obtain an intelligible description of their mechanism. . . . The firing of *dummy shells*, six of which remain, will be resumed to-morrow."

On the 6th the reporter for the New York *Times* said: "The winds blew and the rain descended," and "through the heavy fog of the early morning the thundering reverberations from the *blank charges* with which the guns of the *Vesuvius* were being lubricated were wafted on a biting sea wind across Port Royal and then echoed along the northern shore as far as Beaufort." Other equally fine writing follows this; and we are told that "last week the shots were all successful *to a greater or less degree*."

The public is also gravely informed that "the Board has been greatly desirous of attempting to catch one of the falling projectiles in a fish net. They brought one up from the *Philadelphia* last week, and have been looking for a chance to use it ever since. Until this morning, however, the net was ignominiously resting on the corner of the Navy Yard docking. It was taken down to the 2000-yard line this afternoon and adjusted in the river by means of boats. Before the shell was fired, however, the boats and net were both swept away by the tide, and the effort to use the net will be permanently abandoned."

Then we are told: "After more than a week's suspense, the public curiosity over the tests with loaded shells" (loaded with what?) "will begin to-morrow. The five *gunpowder shells* will be placed in the gun-racks to-morrow morning. . . . The lighter carrying the gun-cotton shells will *remain* at its mooring in Beaufort River, and will probably not be taken down the river until Wednesday morning. . . . Representatives of the press, however, will not be allowed on board the vessel during the tests with gun-cotton shells." (The public may regret that they were excluded.)

On the 7th the *Times'* vivacious correspondent tells the public that "Captain Rapieff arrived. It is now stated that after firing the gunpowder shells to-morrow the *Vesuvius* will go to the naval station and *prepare for the experiments with the gun-cotton shells*."

On the 8th the information was given that "little work other than such as was relative to *future tests* of the *Vesuvius* guns was accomplished to-day. . . . Gunpowder shells will be fired to-morrow; but there is scarcely a hope that the experiments with the high explosives will begin before Monday next."

On February 9 "the execrable weather suspended the tests . . . Half a dozen more of the *wooden projectiles* were fired from the guns. . . . The real work of the day, however, consisted in assembling the parts of Captain Rapieff's wonderful and extremely intricate fuses. . . . Gunner Whitney inspected the high explosive shells and their charges of gun cotton during the day."

On the 10th "the *Vesuvius* resumed her practice." She fired five shots, but whether the shells were wood or metal was not told. They were, however, loaded with something, because one of them, it is said, exploded. Then follows this significant announcement: "Late this afternoon the *Wahneta* towed the lighter, loaded with projectiles, down to the *Vesuvius*, and seven shells were removed to the vessel's deck. *The gun cotton has been removed from these projectiles, and it will be replaced by gunpowder*."

On the 11th four shots were fired, the shells being loaded with 15 lbs. of powder. The *Times'* observer says: "The ability of the tubes to throw a shell with an accuracy certainly not excelled, and possibly scarcely equalled, by powder guns, was demonstrated to the satisfaction of the observers. . . . The question of the efficiency of Captain Rapieff's fuse is just now far more pertinent and decidedly more doubtful. The

fuse is a wonderfully ingenious and intricate piece of mechanism, the practical results of which worked out beautifully on paper. . . . But grave doubts of its efficiency were suggested by yesterday's tests, when five shells were fired, and it was an open question as to whether any of them were exploded. To-day's experiments will increase the impression that the Rapieff fuse may possibly prove a failure. . . .

"It was unanimously agreed by the observers (the Board always excepted) that none of the shells exploded. The lateral line of their fall was practically accurate, and they were reasonably close to their mark; but it was evident that the fuse was not fulfilling its mission. . . .

"Captain Rapieff is very anxious for the tests with the shells loaded with 200 lbs. of gun cotton to begin. If the Board wants a visible effect, Captain Rapieff thinks they will get it then. The Board, however, seems inclined *to feel its way*."

The tests of the guns of the *Vesuvius* thus far seem to have been about as inconclusive as the experiments in rain-making down in Texas last year. A great many people are asking why they do not "shoot dynamite," which was the purpose for which the guns and the vessel were built.

NEW PUBLICATIONS.

THEORY OF STRUCTURES AND STRENGTH OF MATERIALS. By Henry T. Bovey, M.A., D.C.L., Professor of Civil Engineering and Applied Mechanics, McGill University, Montreal. 1893, New York: John Wiley & Sons. 8vo, 817 pages. Price, $7.50.

The numerous text-books on the mechanics of materials, and of roof and bridge structures published in the United States during the past twenty years, have indirectly had the effect of causing the writings of European authors to be neglected. Twenty years ago the works of Weisbach and of Rankine were extensively used as text-books in our technical schools. To-day Weisbach's books are almost unknown to the student, even by name, and those of Rankine, although still maintaining high rank as records of a master mind, are but occasionally consulted. American writers and teachers have produced a literature of their own, distinct from that of England, and but little influenced in later years by the publications of France or Germany. It may, indeed, be said that one of the weak points of many recent books lies in the neglect of European literature, although this has led to strength in other directions. American investigators and authors, if sometimes weak in theory, are often strong in rejecting theoretical speculations based upon insufficient assumptions.

The work before us bears evidence that its author has kept well abreast of the flood of literature produced on both sides of the Atlantic, and has utilized the strong points of each. The student who uses the book cannot fail to find the theory clear and sufficient, the practice sound and authoritative, and the two properly blended, so that each justifies and illustrates the other. At the ends of the chapters are given many problems to numerically illustrate the principles and methods; the student who can solve all these intelligently will have an admirable preparation for practical work as a constructing engineer. No doubt the author has carefully tested in the classroom most of the matter presented.

The book opens with a chapter of 92 pages on Framed Structures, in which graphic methods are mostly employed. Then are given 142 pages on Shears, Moments, and Strength of Materials, followed by 105 pages on Earthwork, Retaining-Walls and Friction. The subject of Beams, Columns, and Shafts occupies 246 pages; Bridges, 106 pages; Suspension Bridges, 37 pages; Arched Ribs, 72 pages, and there is a short chapter of 12 pages on Boilers. The range of subjects is wide, and both advantages and disadvantages occur in treating them all within the covers of a single volume. It would probably be preferable to allow such general subjects as work, energy, inertia, impact, friction and traction to be treated in general works on mechanics, rather than to devote pace to them in a special book on structures.

In the graphical discussions of stresses in trusses the simple notation of Bow is not used, as is customary in both England and the United States, and we see no advantage whatever in the notation substituted by the author. The printer has sometimes failed to grasp the idea that a stress diagram and a frame diagram should be near together, and the confusion is increased when one is turned at right angles to another and is also on the opposite page, as occurs with figs. 86 and 87. The term "intensity of stress," often used in the early part of the book, seems not the best one for students; "stress per square inch" and, more simply, "unit stress" are preferable, and both are used in the latter part. The word "chord" and "flange" are generally employed in speaking of the horizontal members of bridge trusses, although now and then the (to American eyes) strange-looking word "boom" is seen. "Pillar" is often, but not always, used instead of "column." The Latinized plurals "formulæ" and "abscissæ" seem to be generally preferred to the English ones "formulas" and "abscissas." Rankine's theory of the lateral pressure of earth is given, although the assumptions at its foundation have met with little favor in the United States, and the author admits that it gives results too great for good practice. We note on page 634 a discussion entitled "Curve of Cantilever Boom," which seems obscure, for we have been unable to discover either its object or its result, and even the hypotheses (which the author says "are far from being approximately true") are not plainly set forth.

Criticism, however, is always easy, and in hinting at a few minor defects we do not wish to have forgotten our decided conclusion that the work is a valuable text book for students, and one that does much credit to its author for careful and painstaking investigations. Engineers will be interested in the new theory of the flexure of columns involving elliptic integrals, in the lengthy table of actual weights of plate girder and modern truss bridges, in the discussion of the stability of the stone arch, and in many other subjects. In theoretical investigations the book leans toward the methods in vogue in England; in numerical computations and comparisons, its tendency is toward American practice. In this union there is strength.

ANNUAL REPORT OF THE CHIEF OF THE BUREAU OF STEAM ENGINEERING, NAVY DEPARTMENT, FOR THE YEAR 1892 Commodore George W. Melville, Chief of Bureau. Washington; Government Printing Office.

This report has less to say than some former ones of the designing of machinery for new vessels, the number whose construction was authorized during the year having been limited; but it nevertheless presents a record of a great variety of work accomplished in the construction of new engines and the care of older ones. It has some excellent recommendations for the improvement of the service and the betterment of the plants at the different navy-yards where the work has to be done.

The most important new work has been the designing of the engines for the new armored cruiser *Brooklyn* and the battleship *Iowa*, concerning which some interesting particulars are given. The main boilers of the *Iowa* will be the largest yet undertaken in this country; they are to be 16 ft. 9 in. in diameter and 20 ft. long, and the steel plates of the shell will be $1\frac{3}{4}$ in. thick.

Commodore Melville repeats in part some of the observations of previous reports on the weight of machinery, emphasizing his remarks by some instances from the experience of other navies. He finds an improvement in the matter of steel castings, but still believes that there is room for improvement.

The lack of an appropriation has prevented the Bureau from undertaking any experimental work during the year, but there is some work of this kind much needed. The Bureau espe-

cially desires to investigate the use of liquid fuel on board ship. The advantages to be gained by burning petroleum refuse or some similar fuel have often been urged, but it is still uncertain whether the use of such fuel on a naval vessel may not be attended by drawbacks which would more than offset the possible gain, and it is of some importance to ascertain the facts.

The results of building the engines of some of the cruisers in the navy-yard shops have been favorable, and it is probable that more of this work will be done hereafter. Some additions to the plants at the different yards are needed, and the establishment of an additional station at the League Island yard is recommended as a valuable addition to our naval facilities.

A considerable part of the report is devoted to a very earnest plea for the relief of the working force of the engineers of the Navy by an addition to their number. Under the changed conditions of a modern vessel the old force is insufficient for the work actually required, and the conditions are growing worse every year. There is also urgent need of a larger and better force of machinists and petty officers in the engineer department than can be had under present regulations. On these points Mr. Melville speaks very strongly, but not more so than the necessities of the case require.

Atmospheric Resistance and its Relations to the Speed of Railway Trains; with an Improved System of Heating and Ventilating Cars. By Frederick Adams. Chicago; Tribune Building.

This book contains a description of the principles and construction of some inventions by the author to diminish the resistance of railroad trains by lessening the atmospheric resistance, and new methods of ventilating and heating them. The book is admirably printed and well illustrated, but is written in a rather bumptious, reportorial style. In the scientific part the author seems to have followed the practice of the old master mechanic in counterbalancing locomotive wheels, he "figgered awhile and then guessed at it."

The main burden of the book is that atmospheric resistance forms a very large part of the total train resistance, especially at high speeds—which no one doubts—and that this resistance would be very much diminished by enclosing the cars and locomotives in a sort of continuous vestibule—about which there may be a good deal of doubt.

The author says he has six patents which cover "three distinct features of railway train and locomotive construction, thus:

"1. Details of construction of a locomotive and passenger train designed to offer the least amount of resistance to the atmosphere.

"2. A system of ventilation in which the air, free from dust, grime and smoke, is admitted from the front of the train and distributed in suitable quantities through the cars.

"3. A system of car heating in which the hot air around the boiler and fire-box of the locomotive, now wasted, is carried back through the train and properly distributed to heat the cars."

One is disposed to make reply to all that is claimed, in the language of the Hibernian, "to say it is easy, but to do it?" Criticism would perhaps be out of place, because the author forestalls it by saying that his book "is not addressed to those alleged authorities and self-styled experts whose stupidity and ignorance have, for a generation, stood as a stumbling-block in the path of railway science." The critics are expected to stand aside and give the author and inventor a chance to sail in, which no doubt they will be quite willing to do.

White Lead: What We Know about It and Its Substitutes. *A Few Suggestions to Practical Men.* By Oliver D. Goodell. Detroit, Mich.

This little book of 57 pages is devoted to a discussion of the relative merits of white lead and zinc oxide for paints, and is an argument in favor of the latter. A few extracts will give a general idea of the scope of the discussion, which will doubtless interest both the users and manufacturers of paints. The author says:

"Will consumers continue to go forward blinded by hoary prejudice and tradition, and pay into the coffers of this gigantic 'Trust' their hard-earned money, simply because the article is truly and faithfully named Strictly Pure White Lead? Will they not at some future time be willing to buy an article which has more merit, which is more durable, which is sold at a fair figure, and is as truly and faithfully branded what it is—namely, a mixture of lead, zinc, and barytes? These are the questions to be met in the near future. We have assured ourselves that a mixture of lead, zinc, and barytes can be made which will cover better, dry as well, and spread as well as white lead, and while retaining its whiteness and gloss longer than strictly pure lead, will be more durable, and which can be sold at a price less than pure lead, and at a fair profit to the producer.

"We do not object to lead because it is lead; we object to its use in a pure state, because we know that the judicious mixture of other material renders it more durable. It is attempted to make it appear that white lead pure can stand alone, and that white lead pure alone is the only paint that will stand the crucial test of time.

"We take the position that we should not, while admitting that a suitable proportion of white lead has its advantages, admit that we must buy pure white lead for all uses, when we can obtain more durable results with a mixture at less cost.

"Zinc does not affect the oil chemically, but makes a superb mixture of great brilliancy and fineness mechanically.

"It does not injure colors, but, on the contrary, brings them out with clearness and fulness.

"We have frequently painted samples of clean glass, clean iron, clean tin, and clean dry wood with pure lead and pure zinc mixed with linseed-oil, and after they had become dry, exposed them for months to the elements, and in every case the zinc has shown the greatest durability.

"We believe that if we give zinc a fair chance it will hold its own as material for painting."

The Stresses in Statically Indeterminate Structures. Reprinted from *Indian Engineering*. *The Star Press*: Calcutta, 1892.

When a roof or bridge truss has superfluous members the stresses cannot be determined by the principles of statics, and accordingly some other principle or condition is introduced. In trusses with double or multiple systems of webbing, for example, the assumption is generally made that each system is strained only by the loads which rest upon it. The uncertainty of such a hypothesis is, however, considerable, and this is one reason why these structures have for some years been gradually going out of use. The present tendency in truss design is in the direction of simplicity, single systems being mostly in favor, where the stresses are all determinable by the principles of statics. The pamphlet before us contains applications of the principle of least work to the determination of stresses in superfluous members. About one half of its 24 large pages is a reprint of the paper on that subject by Professor William Cain, which appeared in Transactions of American Society of Civil Engineers in 1891, and the remainder gives examples of the methods of computation as applied to

several large roof trusses and arched bridges. The computations appear quite intricate, and most American engineers would probably prefer to make their designs with fewer unnecessary members. The principle of least work, stated in a general way, is that the work of the forces which resist deformation or deflection is a minimum. This appears now to be a principle well established, and one likely to be of value in future investigations in applied mechanics.

BOOKS RECEIVED.

The Mesabi Iron Range in Minnesota. Extracted from the Twentieth Annual Report Minnesota Geological Survey. Horace V. Winchell, F.G.S.A. A history of the discovery of the ore, and a sketch of the extent of this and other ranges, with the varieties, occurrence, and qualities of the ore, with a short account of the mines already opened.

Bulletin du Société Royale Belge de Géographie. November and December, 1892. The leading article is Christopher Columbus and the Discovery of America, followed by a paper on the Course of the Schelde and the Lys-Durme in the Middle Ages.

TRADE CATALOGUES.

EXAMPLE OF A MODERN BOILER PLANT. *Designed and Constructed for Curtis, Davis & Company, Cambridgeport, Mass.* Westinghouse, Church, Kew & Co., Engineers.

The purpose of this little pamphlet of 10 pages is indicated by its title. The mechanism named above is illustrated by, first, a view of the boiler house, a front elevation of the boiler plant, a plan of the boilers, a transverse section through the boiler and stoker, and another through the economizer. Accompanying these is a very good description of the apparatus. The paper, printing, and typography are of the best.

Illustrated and Descriptive Catalogue of the Harrisburg Ideal Automatic Self-Oiling Engines, Simple and Compound. Manufactured by the Harrisburg Foundry & Machine Works, Harrisburg, Pa.

This is a pamphlet of 32 pages, $7\frac{1}{4} \times 10$ in., elaborately illustrated and beautifully printed on coated paper, in the best style of the printer's art. The first portion of it is devoted to illustrations and descriptions of the "Ideal" simple engine. There are, first, beautiful wood-engravings showing a perspective side and end views, and a longitudinal section showing the internal construction of the engine clearly. These are followed by a transverse section through the crank-shaft, a section of the valve-stem and crosshead, and a side view and plan of the connecting-rod, longitudinal section of crosshead section of cylinder relief-valve, side view longitudinal and transverse section of piston-valve, similar views of the piston, and an end view of the governor. Accompanying these engravings is a very full and clear description of the engine, its construction, operation, and advantages, all models for this kind of literature and authorship.

The second portion of the catalogue is devoted to the "Ideal Tandem Compound Engine," which is illustrated by perspective views of the two sides of the engine and a sectional plan which shows its construction very clearly. The accompanying description is also clear and concise, which is followed by tables giving the sizes, horse-power, etc., of the engines which are manufactured by the firm.

A very good illustration is also given of an "Ideal Cross Compound Engine," and the book concludes with illustrations showing sectional views of the "Weitmyer Patent Boiler Furnace for the Better Combustion of all Fuels, Abatement of Smoke, and Obtaining greater Boiler Efficiency," and a very good perspective view of Harrisburg Double Engine Steam Road-Roller.

Altogether this catalogue may be very highly commended as an example of this kind of literature. Of the engines illustrated we hope to speak more fully in the future.

CURRENT READING.

RECIPROCITY, which has been published in Philadelphia for the last year, has now been issued under the name of *Traffic.* The policy of the paper will remain unchanged, and there will be a vigorous discussion of international questions as heretofore.

NOTES AND NEWS.

New Steamer for the Old Colony Line.—President Choate has asked authority of the Massachusetts Legislature for authority to capitalize the stock of this company at $2,000,000, with a view to building a new steamer to cost $1,250,000.

Chicago Train Service.—The recent tabulation shows that 1,386 trains of all classes arrive and depart daily at Chicago. This traffic is carried on over 41 roads operated by 28 companies. Of these, 28 trains are through expresses and mail trains; 670 suburban and accommodation; 274 merchandise freight trains, and 164 grain, stock and lumber trains. The 28 companies operating these trains own 40,000 miles of railroad.

Jaffa & Jerusalem Railway.—Selah Merrill, United States Consul at Jerusalem, and author of the well-known book "Beyond the Jordan," has written for the March *Scribner* an account of the opening of the Jaffa & Jerusalem Railway in August last, with a description of the origin of the project more than thirty years ago in the brain of an enterprising American, the inventor of a famous pill.

Exhibition Number of "Scribner's."—Charles Scribner's Sons are preparing a novel and interesting contribution to the World's Fair in the form of an "Exhibition number" of *Scribner's Magazine*, to be published simultaneously with the opening of the Exposition at Chicago. It is not proposed that the text shall relate chiefly to the Fair, but, on the contrary, the leading writers and artists have been asked to contribute to the number what they themselves think will best represent them.

Crushed Steel.—A correspondent of the *Indian Engineer* says: "Crushed steel is fast coming into use for cutting stone. It appears to be made by quenching very high carbon steel in cold water, from an excessively high temperature, such as would overheat steel for most purposes. This renders it not only hard, but rather brittle, so that it is possible to pulverize it. It is crushed in a stamp-mill, and sifted closely to size. It is said to be not only cheaper, but much more effective than emery, giving a better polish and quicker, and lasting much longer."

A Bridge at Duluth.—Another bill for the construction of a bridge across the St. Louis River, between the States of Minnesota and Wisconsin, near the village of West Duluth, has been introduced into Congress. The bill provides that the bridge shall be constructed for the passage of railroad trains, and may be used as a wagon bridge, with rates of toll approved by the Secretary of War, or it may be operated without toll or charges, provided an agreement is reached between the municipal government having jurisdiction over the territory and the corporation building it. It provides for a pivot drawbridge over the main channel of the river at an accessible and navigable point.

Books Handled by Machinery.—In the library of Congress, which has over 650,000 bound volumes, the books will hereafter be handled almost entirely by machinery. Orders will be sent to the book-stacks, and books brought from them to the desk for distribution by trays suspended from endless chains, the latter being made to travel by means of an engine in the basement. The mechanism will be noiseless and invisible also, the carriers going beneath the floor of the great central reading-room, to and fro between the librarian's desk and the book-stacks. Every arriving tray will dump itself auto-

matically at the first desk. Likewise, in taking volumes back, each tray will spill its contents, of its own accord, at a certain tier.

Destruction of Valuable Engines.—The Delaware & Hudson Canal Company recently had a fire in its round-house, in which there were three engines; one—the poorest of the lot—was rescued, while the two most valuable were destroyed. This reminder suggests the desirability of constructing round-houses so that, in case of fire, valuable engines may be removed before they are destroyed. Some of the new houses of this kind are constructed with separate stalls placed diagonally, with a separate track arranged for each house and each engine. This permits of the removal of all the engines from the stalls excepting that in which the fire occurs.

A Long Run with Little Oil.—Mr. W. H. Lewis, Master Mechanic of the Chicago, Burlington & Northern Railroad, has been making an experiment to determine as to just how far the cylinders of an engine could be made to run on a pint of oil. The average consumption had been about 65 miles on a pint. He selected an engine that was in good condition and placed a competent engineer in charge, explaining that he wished to demonstrate just how far it is possible to run on a pint. The lubricator was filled and soldered shut. The lubricator held a trifle more than a quart, and when it was emptied the engine had run 1,720 miles, or over 800 miles to the pint. An examination of the valves and cylinders showed them to be in perfect condition.

Consumption of Coal.—*The Coal Trade Journal* gives the following list showing the percentage of coal shipped from the works by rail, consumed at the collieries for steam and other purposes, and locally sold to employés and others residing adjacent to the collieries:

Of the first, or shipments..............87¼ per cent.
Of the second, or colliery boiler use.....11¼ per cent.
Of the third, or sales locally............ 1½ per cent.

And this with a large local outside trade.

It has been commonly estimated that 5 per cent. was a fair figure to take for colliery boiler use, while about an equal amount was sold at the collieries. The above figures prove how erroneous the *estimates* heretofore made were when compared with this actual data.

Suppressed Patent Improvements.—A bill has been introduced to prevent the suppression of improvements in inventions. The measure proposes to add a section to the statutes on this subject providing that no patent shall, by reason of a broad or dominating claim or otherwise, prevent the practice or use of any patented actual improvement in the invention forming its subject-matter, provided the patentee or owner of the improvement shall pay a reasonable royalty or tribute to the owner of the patent having the dominating claim, the amount of royalty or tribute to be determined by a court of the United States, the court to take into consideration the profits, past or prospective, to the owner of the improvement and the damages of the dominating patent, similar as in the case of a decree for infringement.

Inter-Continental Railway.—The Inter-Continental Railway Commission has had prepared a facsimile in miniature of Central and South America to show the surveys of the proposed railroad intended to unite the systems of North and South America. The work was done by E. E. Court, of the hydrographic office, and is a faithful representation of the topography of the countries named. It is about 25 ft. long, and will be sent to the World's Fair as a part of the Government exhibit. In addition to the lines surveyed for the railroad the map also shows the routes of the present and prospective steamship lines from North to South America, with the names of their terminal ports and intermediate stopping points, if any.

Honors to Commodore Melville and Constructor Wilson.—The Institution of Naval Architects, of England, has admitted to honorary membership Engineer-in-Chief Melville and Chief Naval Constructor Wilson, in consideration of their services in marine construction and design.

This is the most famous association of its kind in the world; and the distinction is all the greater for the reason that, besides Messrs. Melville and Wilson, there are only three honorary members of the institution. These are gentlemen who have won, in their own countries, a reputation similar to that achieved by Commodore Melville and Constructor Wilson in the United States. Mr. C. A. Griscom, the President of the Inman Line, was admitted as an honorary associate, of which, including Mr. Griscom, there are five.

Coal in Arizona.—Coal is reported near Flagstaff, Ariz. The coal lies in a 6-ft. vein, is free from all objectionable properties, and cokes perfectly. Two companies have been formed to develop the mines, and are making arrangements to work the properties extensively. The coal is found in two localities, 50 and 90 miles, respectively, northeast of Flagstaff. In view of the fact that the Grand Cañon is only 30 miles from these fields, and contains some of the largest and richest copper mines in the continent, the coke produced from these mines is likely to prove a bonanza. The line of the proposed Flagstaff & Grand Cañon Railroad runs very near these fields, which fact is likely to give a new impetus to the building of the road.

New Ships for the International Steamship Company.—This company, which is the successor of the Inman Line, intend to have built at least six steamships in America, all equal at least to the *City of New York* and the *City of Paris*, which was fulfilling their agreement with the United States Government more than the requirements stipulated, these demanding that only two steamships be built here in size and speed equal to the vessels which are to fly the American flag beginning February 22. It is intended to have all the new ships capable even of greater speed than the company's English boats. Some of the new vessels are to be put on the Red Star Line, which the International Company controls, and whose steamships are to stop at Southampton, England, and Boulogne, France, on their way to the terminal port of Antwerp.

Work on the new vessels has already been practically begun by the Cramp Ship-building Company, Philadelphia.

A New Anemometer.—An anemometer which records both wind direction and velocity upon a cylinder by one symbol has been devised by Professor Klossovsky, of the Odessa Observatory. The recording apparatus is moved by clock-work, and the indications are made by electrical contacts. The duration of the contact depends upon the velocity of the wind, a light wind producing a contact of longer duration than a strong one. The indications are by means of arrows printed on the paper covering the cylinder, which show the direction of the wind, and the number of arrows marked on a length of paper corresponding to one hour furnishes data for finding the velocity by an empirical scale determined by comparison with a Robinson anemometer. The apparatus only requires to be adjusted twice a month, or in some instruments only once a month, and calls for no attention in the meantime. One cell is sufficient to produce the contact, for most of the work is done by means of weights.—*Engineer.*

A Great Mississippi River Bridge.—President Harrison has signed a bill which authorizes Chicago men to construct over the Mississippi River at New Orleans the largest cantilever bridge in America. Surveyors and engineers will soon begin preliminary operations, and within three years the $5,000,000 structure will be opened for traffic. The plan is one in which all the railroads in the South are interested, and the contract has been given to Corthell & Kerner, civil engineers of this city. The bridge must be built of steel with two piers in the river. The length of the main channel span will be 1,095 ft. and the two side spans 757 ft., with the lowest part of the superstructure not less than 85 ft. above the extreme high-water mark. The charter granted by Congress provides that one approach, if practicable, shall be within the city limits of New Orleans. The place now practically selected for it, however, is at Nine Mile Point, and not far from Carrollton.

A Long Trolley Road in Pennsylvania.—A charter has been granted in Pennsylvania for a trolley line of railroad 80 miles long. The road is called the Northumberland, Bloomsburg & Scranton Street Railroad Company, and connects 39 towns in that region. Among them are Lackawanna, Pittston, Catawissa, Mechanicsville and Nanticoke. It is a very busy center, and the establishment of a trolley line would materially interfere with the local traffic of the steam roads. At the office of the Reading Railroad Company it was stated that these roads were generally given the privilege to run over the turnpikes and township roads, thus saving the expense of grading, the largest item of the steam roads' expense in a mountainous country. It was acknowledged that it would make a difference in the revenues of the companies with which such road came in competition. The capital of the new road is $500,000, and it is said that a syndicate in Philadelphia is furnishing the money.

For the Pennsylvania Railroad Company.—This company, it is said, has recently bought the southern half of the block bounded by 38th and 39th streets and 11th Avenue and the Hudson River. About five years ago the same company

purchased all the adjoining block between 37th and 38th Streets and 11th Avenue and the Hudson River, except so much as extended for 100 ft. west of the avenue front. It would thus appear that the Pennsylvania Railroad Company had entered upon a policy of acquiring large slices of land in this city.

What it means to do with this ground has been matter of speculation in railroad circles. That it will be made contributory to its terminal facilities in this city is evident; but how it will be built up, if at all, is the interesting question. It is said by one of its representatives in New York that if the company had bought it they would use it merely for tracks, just as they were using the ground in the next block, and would not build it up at all, much less in a "mammoth" or costly manner.

The Morgan Line's New Steamer, "El Rio."—This vessel, built after designs of Mr. Horace See, reached New York recently, on her maiden voyage, direct from the yards of the Newport News Ship building Company, where she was launched November 26. She will proceed, about the middle of next week, to take on board freight for New Orleans.

The new ship has a length over all of 406 ft., a beam of 48 ft., and a depth from the top of the keel to the under side of the upper deck of 33.9 ft. Her tonnage displacement measures 4,500 tons.

She is designed for a 16-knot speed per hour. Her motive power consists of a vertical, inverted, triple-expansion engine, having cylinders measuring, respectively, for high, intermediate and low pressures, 32, 52 and 84 in. The stroke is 54 in. The working steam pressure will be 167 lbs. Steam will be generated by three double-ended Scotch boilers, having three furnaces at each end. Each furnace is of the corrugated type. In rig, *El Rio* is provided with two masts. A sister of *El Rio*, named *El Cid*, is now on the stocks at the Newport News yards. *El Cid* is to be a steel ship, and in general dimensions and internal arrangements a duplicate throughout of *El Rio*. The new ships will be used solely as freight steamers.—*New York Times.*

Economy of Gas-Engines.—An electrical paper says that "the waste involved by the intervention of the steam-engine, with the clumsy modes of raising steam and the clumsier ways of utilizing it, are apparent to any one who looks into the calorific value of fuel." That is a sort of preface to the statement that gas-engines are "beating the steam-engine, both in fuel consumption and in general economy." Then it proceeds, "It is to be hoped that some central stations in this country may be induced, at all events, to try a supplementary gas plant or two for day loads or for emergency use." If the gas-engine is so very economical, why use it merely for emergency purposes? The position of the gas-engine is well understood, and users of steam are quite aware that they do not get the full value of the fuel; but no "electrician" has yet attempted to improve on the "clumsy methods of raising steam" except the man who was going to use electricity to raise the steam that produced the electricity. He is still "going to."—*English Mechanic.*

Bi-metallic Wire.—Herr Elsässer recently remarked before the Electrotechnischer Verein, of Berlin, that besides the bronze wire already used in telephone installations, and which during the past year has also come into favor for telegraph service, several other kinds of wire have been employed experimentally, among them the so-called compound wire, consisting of a cast-steel core and an outside layer of copper. This wire, it is said, has proved very satisfactory, and has specially commended itself for service along the sea-coasts, where there is much exposure to fog and dampness generally. It is reported to have been found that in this wire the copper exterior adheres perfectly to the steel body, and does not tend to peel off even after bending the wire a number of times. One of the other kinds of wire under trial consisted of an aluminium-bronze core with a copper-bronze envelope. This wire, which is said to be of great tensile strength, and to have a comparatively low electrical resistance, is considered specially adapted to take the place of the plain bronze wire already in use.

Readjusting a Misfit Jacket.—It is understood that the attempt to place the "misfit jacket" of the big gun at the ordnance yard recently was a failure. After two heatings the jacket was moved only four inches, leaving it eight inches out of place. After the tremendous heating to which the end of the tube and its jacket was subjected to in the effort, there are grave doubts whether the gun can ever be relied upon, even if the efforts to force the jacket into place shall be finally successful, for the condition of the steel must have undergone a radical alteration in molecular structure, so that its strength and all the other characteristics as gun metal must be a matter of surmise alone. A beautiful experiment was made a few years since at Fried Krupp's famous gun factory at Essen, whereby a completely finished gun of considerable caliber was "disassembled" by the employment of a spray of liquefied carbonic acid gas. The inner tube was sprayed with this intensely cold fluid, with the result that the contraction was sufficient to permit of the jackets and other portions of the gun to be removed without injury to either temper or mechanical fit.

An Atlantic Derelict.—There is a vessel drifting about the Atlantic with a cargo valued at $20,000, and a most remarkable circumstance in connection with the craft is that it has been drifting about for nearly two years, and has traveled a distance of 5,000 miles. The vessel is the *Wyer G. Sargent*, and she started on her voyage from Laguna with a cargo of Mexican mahogany in the month of March, 1891. She got dismasted in a hurricane, and her crew were saved by a Norwegian vessel. The *Wyer G. Sargent* is a vessel of 1,500 tons register, and since her abandonment she has been passed twenty-seven times by various ships. The last time she was sighted was on October 12 by the steamer *Asiatic Prince*, about 900 miles from Bermuda. Her decks were then awash, but the bow was well out of the water, and it is said that there was little or no alteration in her condition since the time she was abandoned until she was last seen. She showed no signs of breaking up, and it is probable that she will drift about for a long time yet, unless she is cast somewhere ashore. The *Wyer G. Sargent* has twice crossed the Gulf Stream in her derelict state, and was known to be at one time within 250 miles of Bermuda, and at another 600 miles from the Azores.

Weight of a Crowd.—In a paper by Professor Kernot, read before the Victorian Institute, he compared the various estimates as to the weight per square foot of a crowd. One estimate, quoted as French practice by Stoney and Trautwine, gives 41 lbs. per square foot as the weight of a crowd. Hatfield, in "Transverse Strains," gives 70 lbs.; Mr. Page, engineer to Chelsea Bridge, 84 lbs; Mr. Nash, architect to Buckingham Palace, quoted by Tredgold, 120 lbs.; Mr. W. N. Kernot, at Working Men's College, Melbourne, gives the weight as 126 lbs.; Professor W. C. Kernot, at Melbourne University, puts it at 143.1 lbs; and Mr. Bindon B. Stoney, in his work on "Stresses," as 147.4 lbs. per square foot. The space occupied by soldiers, as taken by Hatfield in his estimate, is not the same as a crowd. Soldiers are arranged in lines at a distance apart to allow room for knapsacks and other accouterments; but a crowd is forced together into close contact, an average man in a crowd occupying a space of little if any more than 1 sq. ft. On the whole, Professor Kernot inclines to favor Mr. Stoney's estimate of a little more than one man per square foot, and gives it as proved that a dense crowd of well-grown men weighs between 140 lbs. and 150 lbs. to the square foot.

Coal Supply of Europe.—A pamphlet in relation to the coal supply of Germany and other nations has just been published in Berlin by the Minister of Commerce, and contains some interesting figures. The coal supply of Germany in the districts of the Ruhr, the Saar, Aix la Chapelle, Upper and Lower Silesia and Saxony is estimated at 112 milliards of tons. At the present rate of consumption, it is declared, no want of coal would be felt in the poorest coal beds for 250, or in the richest ones in Westphalia for 1,000 years. Twenty years ago the coal supply of Great Britain was reckoned at 198 milliards of tons. Estimating the supply of France at approximately 18, of Austria-Hungary at 17 and of Belgium at 15 milliards of tons, the Central European States are held to possess a coal supply of 360 milliards of tons. The writer comes to the conclusion that a want of coal will make itself felt first in Austria, France and Belgium, then in England, and last of all in Germany. The average consumption of coal in Germany per head of the population only amounted in 1890 to 1.66 tons, whereas in England it was 4.81 tons. The author does not introduce into his comparisons either the coal supply of Russia or that of America, as he is of opinion that the coal of those countries will never be of importance to the States of Central Europe.

The "American Line" of Steamers.—With the opening of the new American Line service between New York and Southampton in February, the favorite steamships *City of New York* and *City of Paris* will be transferred to the American flag in accordance with the act of Congress, and the old trade name of Inman Line will be dropped for this express service. The words "City of" will also be dropped from the name of

the steamships, and thereafter they will be known as the *New York*, *Paris*, *Berlin*, and *Chester*.

The two new steamships being built for the coming successors of the Inman Line will be twin-screw steamships of somewhat larger tonnage than the *New York* and *Paris*. The engines will be of the latest type, and the steamers will make a speed of 20 knots, as required by the contract with the United States Government for carrying the mails. They will, of course, be under the American flag, and will be built so as to be readily convertible into Government cruisers and capable of carrying the armament required by the law. Their speed and very great coal endurance will make them an invaluable auxiliary to the national navy, and without any further cost to the Government than the moderate pay allowed for carrying the mails. These ships are already under contract with the William Cramp & Sons' Ship & Engine Building Company, and plans are nearly completed for three more.

A Fast Boat.—C. D. Mosher, the designer of the fast craft *Norwood*, is now completing a 78-ft. boat, with 9 ft. 6 in. beam. The engine is of the quadruple compound type with cylinders in a straight line, supported over an elliptical base of cast and wrought iron by means of slender and steel vertical pillars, each pair of which are braced with straining rods in the form of an X, split down through the point of crossing and provided with a screw by which the braces can be strained until all racking is obviated. The stroke of the engine is 10 in., and the cylinders are respectively 9½, 13¼, 18, and 24 in. in diameter. Every ounce of superfluous metal has been removed from the castings forming the cylinders. It is estimated that the complete engine will weigh less than 3,600 lbs., and that at a speed of 500 to 600 revolutions it will develop from 500 to 600 H.P., with a steam pressure of 250 lbs. To secure the minimum of weight with the maximum of strength, all of the working parts have been reduced to the smallest practical dimensions, or else relieved of superfluous metal at the center by boring. The rock-shafts have 1-in. holes through them. The piston and connecting-rods are hollow, and the big crank-shaft has been bored out whenever a tool could be used upon it. This shaft was carved out of solid steel forging weighing 2,012 lbs. It now weighs 414 lbs. The engine when set up will occupy less than 14 sq. ft. of floor space. Steam will be furnished by a pipe boiler of peculiar construction, and is built with a view of standing great pressure, occupying little space, and steaming rapidly.—*American Shipbuilder*.

Properties of Matter at very Low Temperatures.—Professor Dewar recently lectured in the Royal Institution in London upon the results of some of his investigations of the properties of matter at very low temperature. Liquid oxygen, until recently, was only produced in very small quantities, but Professor Dewar produces it by the pint, and is able to demonstrate its beautiful blue color, its magnetic quality, and its characteristic spectrum. As oxygen boils at 182° below zero, the preservation of it in a liquid condition for any time has been practically impossible, but the problem has been solved by the discovery that evaporation can be checked by surrounding the vessel containing the oxygen by a very high vacuum. The London *Times*, in its report of the lecture referred to, says: "Many remarkable phenomena were shown, but none was more worthy of attention than the little bulb of liquid oxygen, something between a walnut and a golf-ball, which hung in a clip upon the lecture table. It was filled and hung up at an early period of the lecture, and it remained four-fifths full at the close. If a conjurer had made his appearance with a large vessel of boiling water and a brisk fire beneath, and if in that water he had boiled for half an hour a piece of ice as big as a golf-ball without reducing it by more than one-fifth, every one would have been vastly astonished. But the little bulb full of liquid oxygen was far more wonderful. The difference of temperature between the conjurer's ice and his boiling water is 100° centigrade. The difference between the temperature of Professor Dewar's bulb and the air of the theater was not less than 210° centigrade. Yet, though that scorching blast necessarily had free access to the oxygen in one direction, the liquid was so perfectly protected by its vacuum jacket as to attain that relatively high degree of permanence."

The Deduction of a Right Line.—*The Worcester* (Mass.) *Spy* says: "G. Vailati, Professor of Mathematics in the University of Turin, Italy, has sent to Clark University an article just published by himself giving an elaborate geometrical formula for the deduction of a right line. He had just received from B. I. Gilman of the university a copy of an article printed by him at the same time and treating the same question, although from a psychological standpoint. The remarkable thing is that these two investigators—one in Worcester, one in Turin; one from the psychological, and the other from the mathematical standpoint—should have reached, independently of each other, not only the same general conclusion, but the same set of mathematical formulæ for expressing that conclusion. This is a striking illustration of a number of things—viz., of the close interdependence of very distinct departments of research, of the accuracy of method which reaches identical results from such different data, and of the fact that discoveries come when and where the time is ripe for them."

[Will not some of our readers who are well up in mathematics explain to those who are not what "the deduction of a straight line means"? We have known people who could not "deduce" a straight line, but they were generally intoxicated. We have also known a man who could not understand mathematics, because "the axioms were not self-evident" to him. He was not convinced, he said, that the shortest distance between two points was a straight line. He thought it was quite possible that some kind of a crooked line might exist which would be shorter than a straight one. This man was not intoxicated either. The "psychological deduction of a straight line" we are quite sure must be an intensely interesting subject.—Editor American Engineer.]

Trial of Harvey Steel Armor-plate.—A few weeks ago a Harvey nickel steel armor-plate, 6 in. thick, was tested on board the *Nettle* at Portsmouth. The 6-in. breech-loading gun was used, firing Holtzer's forged steel projectiles weighing 100 lbs. each. The trial was of a very unusual kind, the gun and projectile being those regularly employed for testing 10½-in. plates, except, indeed, that for two out of the five rounds constituting the usual test Palliser chilled iron shot are used, whereas in this case four rounds were fired with Holtzer projectiles. It was out of the question to attack this plate with the usual charge and striking velocity, and the following order was observed: Round 1 was fired with a charge, we believe, of 30 lbs.; at all events, the striking velocity was 1,507 ft. per second. The projectile was pulverized without cracking or seriously injuring the plate. Round No. 2 was fired with, we believe, 42 lbs. of powder. The striking velocity was 1,813 ft. per second. The shot was again broken up, but the plate was cracked. No. 3 round was fired, we believe, with 48 lbs. of powder. The striking velocity was 1,960 ft. per second. The projectile perforated the plate and was lodged in the form of fragments in the backing. No. 4 round was fired with the charge again reduced, so as to give a striking velocity of 1,815 ft. per second. The shell was again broken up without perforation, and no further cracks were made, and no part of the plate fell off from the backing.

This is a most remarkable trial, for it must be borne in mind that the resisting power of a plate is more nearly as the square of its thickness than as the first power, so that for a 6-in. plate to break up a projectile which until recently was a match for 10½ in. is a great triumph, and it may be seen from the account that any structure behind the backing would have been protected. Attention must be called to the fact that while the shot was broken up at 1,815 ft. velocity in such a way that a great part of its striking energy must have fallen harmlessly on the plate, it cannot be argued, on the other hand, that a shot is only capable of delivering a fixed quantity of energy before facture, and that all energy over and above that is lost, for it appears that at 1,960 ft. velocity much more injury was done, because we suppose more energy was delivered before the work of fracture was complete. Probably the fracture of the projectile occupies such a period of time that more work is done on the plate by increasing the velocity, because although the shot is the weakest element, there is not time to find the line of least resistance before additional injury is done to the plate. It is perhaps the same action as causes fulminate not to follow the lines of least resistance taken by slower powder in bursting a vessel.—*The Engineer*.

Bacterial Purification by Light.—The bacterial purification which takes place in a river during its flow has been recently attributed in part to the process of sedimentation which the micro-organisms in the water undergo, but it would seem that yet another factor must be taken into account. Buchner, in some investigations which he has recently published, shows that this diminution of the numbers present may be also assisted by the deleterious action which light exercises upon certain micro-organisms. A systematic series of experiments was made by introducing typhoid bacilli, Koch's cholera spirilla, also various putrefactive bacteria, into vessels containing sterilized and non-sterilized ordinary drinking water. As a control, in each experiment one vessel thus infected was exposed to light, while a second was kept under precisely similar conditions, with the exception of its being covered up

with black paper, by means of which every particle of light was excluded. The uniform result obtained in all these experiments was that light exercised a most powerful bactericidal action upon the bacteria in the water under observation. For example, in one water in which at the commencement of the experiment 100,000 germs of typhoid bacteria were present in a cub. cm., after one hour's exposure to direct sunlight *none* were discoverable, while in the darkened control flask during the same period a slight increase in the numbers present had taken place. Even the addition of culture fluid to the flasks exposed to sunlight could not impair in the least the bactericidal properties of the sun's rays. In the flasks exposed to diffused daylight the action was less violent, but still a marked diminution was observed. In his later experiments Buchner has employed agar-agar, mixing a large quantity of particular organisms, pathogenic and others, with this material in shallow covered dishes and then exposing them to the action of light and noting its effect upon the devlopment of the colonies. For this purpose strips of black caper cut in any shape (in the particular dish photographed py Buchner, letters were used) were attached outside to the bottom of the dish, which was then turned upward and exposed to direct sunlight for one to one and a half hours and to diffused daylight for five hours. After this the dish was incubated in a dark cupboard. At the end of 24 hours the form of the letters fastened to the bottom of the dish was sharply defined, the development of the colonies having *taken place in no part of the dish, except in those portions covered by the black letters.* Some interesting experiments on the same subject have also recently been made by Kotljar. In the course of these investigations the author found that of the colored rays of the spectrum the red favored the growth of those bacteria experimented with, while the violet rays acted prejudicially, although less so than the white rays.

COMPOUND EXPRESS LOCOMOTIVE FOR THE NORTHERN RAILWAY OF FRANCE.

On the opposite page we illustrate a new compound express locomotive which has been built for the heavy express traffic of the Northern Railway of France. The engine is a development of another compound express engine built in 1886, and which, in spite of some minor defects, has given, on the whole, very favorable results in the matter of economy of running expenses and maintenance. The new engine has been constructed by the Société Alsacienne de Constructions Mécaniques, Belfort, to the designs of M. Du Bosquet, Locomotive Superintendent of the line. The engine is four-coupled, and has four cylinders, namely, two high-pressure and two low-pressure cylinders, the former being 13.4 in. in diameter, and the latter 29 in., with a stroke in each case of 25.2 in. In our next issue we shall publish further details of this engine, and defer our description until then. We are indebted to *Engineering* for the engraving.

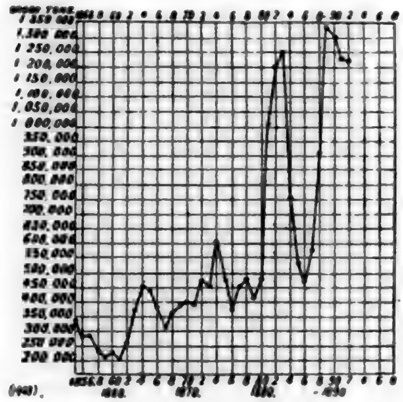
FOREIGN MARINE NOTES.

A New Armored Coast-Defense Ship—the *Admiral Oushakoff*—is being built for the Russian Navy. This vessel is of the monitor type, with low freeboard and two turrets, each carrying two heavy guns. She will draw about 14 ft. of water on 4,150 tons displacement, and has twin screws with engines of 4,500 H.P. In addition to the turrets there is a barbette in which several rapid-fire guns will be carried.

The latest addition to the Italian Navy is the *Marco Polo*, second-class ironclad, recently launched at Castellamare She belongs to the class of torpedo-rams, but is larger than those already existing in the Italian Navy. Her principal armament will be six 6-in. cannon, four of which will be under deck, while the other two will be placed in turrets at the prow and stern of the vessel, and ten other cannon of 4.7-in. bore within decks. There will be four torpedo-tubes above water on the battery, and one under-water tube at the prow. There will be other minor artillery, and a powerful ram below the surface of the water. The *Marco Polo* is 330 ft. long and 4,460 tons displacement; she has two screws, each driven by a compound engine.

Leaky Tubes.—Hiram S. Maxim says of leaky tubes: "In experiments which I have been conducting during the last two years, I find that where the fire is very hot and the heating surface very great in proportion to the water, a forced circulation is a *sine quâ non*, and this is very easily accomplished without the aid of any other machinery than that already employed on shipboard. Suppose that the boiler pressure should be 150 lbs. to the square inch; I should then have the pressure of my feed-water 200 lbs. to the square inch, and should have it escape from the feed-pipe into the boiler through a small orifice, which may be automatic, and which will maintain a constant difference of pressure of 50 lbs. to the square inch between the water in the feed-pipe and in the boiler. This will give a solid stream of dense water escaping through an orifice with a force of 50 lbs. to the square inch, and this can be made to operate on ten times its volume of the surrounding water in the boiler after the manner of an injector.

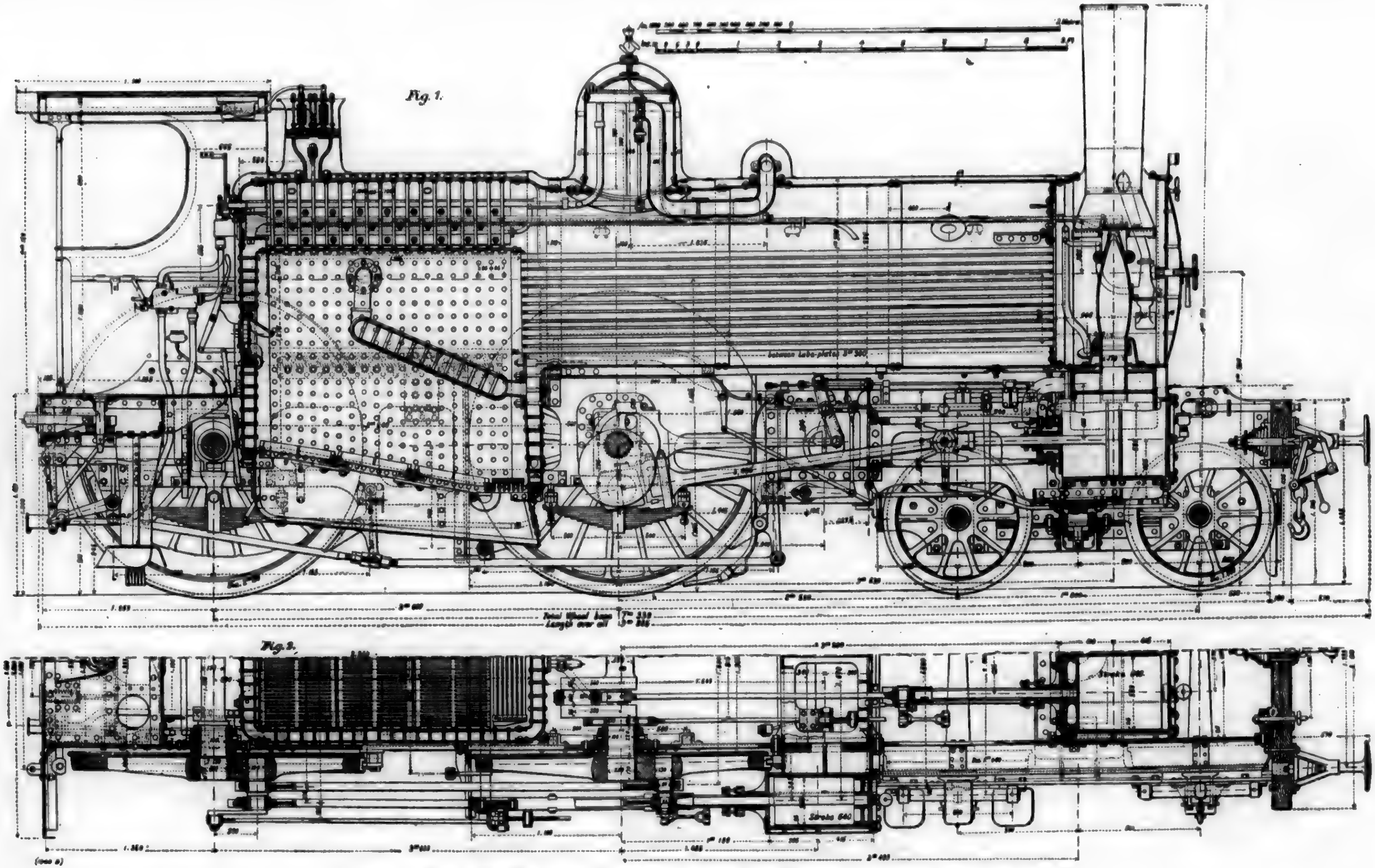
Ship-building in the United Kingdom.—The accompanying diagram, copied from *Engineering*, was prepared by Mr. William Cooper, Steamship Surveyor Newcastle-on-Tyne, shows the gross tonnage of all vessels built in private yards in the United Kingdom, including war-ships and foreign-owned craft, from 1855 to 1892 inclusive. The alternations between times of severe depression and great activity are well illustrated.



The "Lucania."—The new steamer of the Cunard Line was launched on February 2, at the yard of the Fairfield Company, Govan, near Glasgow. She is a sister ship of the *Campania*, built for the Cunard Company at the same yard. The dimensions are: Length over all, 625 ft.; breadth, 65 ft.; depth, 41 ft., and nearly 13,000 tons in measurement. The *Lucania* is 20 ft. longer and 7 ft. broader than the *Teutonic* or *Majestic*, and is intended to accommodate 450 first cabin, 250 second cabin, and 600 steerage passengers. It is expected that the *Lucania* and *Campania* will lower the ocean record.

Fast Atlantic Line for Canada.—There is some talk in Canada of a fast Atlantic service between Montreal and Great Britain, but it is not at all probable that the scheme will be carried out. At present the service between the two countries is such that the freight rates and ordinary passenger service is satisfactory, and there is not a demand for quick travel sufficient to warrant the construction of record breakers and the granting of a government subsidy, which would be necessary in order to keep the line alive. The Government has not as yet, however, committed itself in the slightest degree either for or against the project.

Fast Torpedo Boats.—The famous torpedo-boat builder at Elbing, Schichau, has just attained an unprecedented speed even for this class of vessel—torpedo boats built by him for the Russian and Italian governments having reached 27¼ knots on an hour's run at sea. The new British boats are to be 200 tons displacement, while the Russian boats are 130 tons, so that the former may do better by reason of greater power and greater size. The length of Schichau's boat is 152 ft. 6 in., the beam 17 ft. 5 in. She may carry 40 tons of coal in her bunkers. On trial, however, she had only 20 tons on board. The small guns carried weighed 2½ tons; the torpedo armament, 6 tons; the crew, provisions, stores and firearms, 4¼ tons; drinking water, 2½ tons; engine and boatswain's stores and reserve parts, 4¼ tons; so that all the movable parts come to 20 tons, making, with coal, 40 tons. The vessel and the ma-



COMPOUND EXPRESS LOCOMOTIVE FOR THE NORTHERN RAILWAY OF FRANCE.

chinery are, therefore, very light. The shell plates are barely a quarter of an inch thick. There are two locomotive boilers, protected by the coal bunkers, supplying steam at 195 lbs. pressure to high-speed engines. The guaranteed speed was to be 26½ knots in the open sea, while on trial the vessel actually made 27½, or, to be precise, 27.4 knots, as a mean of one hour's steaming at sea. Schichau promises even higher results with torpedo boats he is now completing.—*Steamship.*

New Shaft for the "Umbria."—Messrs. Vickers' Sons & Company, River Don Works, Sheffield, have been instructed by the Cunard Steamship Company to make a new thrust shaft to replace the one recently broken on board the *Umbria.* The ingot from which the shaft was forged under the press weighed 55 tons. Exclusive of the collars, which have each a diameter of over 3 ft., the shaft is to have a diameter of 25 in., with a length of 20 ft. The old shaft, which was also produced at the River Don Works, was made in 1884, and has consequently done duty for eight years. The new shaft is about ready for delivery. Messrs. Vickers are now engaged upon an order for five 68-ton guns for the British Government.

The new Italian battle-ship which is building at Venice, and has been named *Ammiraglio di Saint Bon*, in recognition of the great services of the late Minister of Marine, is of a new type, and will have a displacement of 9,800 tons, a length of 344 ft. 6 in., a beam of 69 ft. 3 in., and an extreme draft of 24 ft. 8 in. With forced draft she will develop 13,500 H.P., and steam at 18 knots speed; with natural draft a speed of 16 knots will be obtained, with an expenditure of about 9,000 H.P. There is an over-all protective deck of steel, varying in thickness from 1½ in. to a little over 3 in. An armored citadel, in the middle of the vessel, and the armored belt will carry plates varying from 4 in. to 9¾ in. thick. At each end of the citadel will be a turret armed with two 9.9 in. guns. Elsewhere, with suitable shields, will be mounted eight 5.9 in., eight 4.7 in., four 2.2 in. 6-pdrs., and 12 small quick-firing or machine guns. The coal-carrying capacity is to be 1,000 tons. It was originally proposed to call this ship *Christoforo Colombo*, a name which has been given to an unarmored cruiser. Two similar vessels are ordered to be built, one at Spezia and the other at Castellamare. Each will have twin screws, triple-expansion engines, 12 boilers, traverse armored bulkheads, double bottoms throughout, a great number of water-tight compartments, and, in fact, every modern improvement. The definite abandonment of the over-large gun by the Italian Navy, which, for the *Duilio*, launched in 1876, was the first to adopt it, is noteworthy. No Italian ironclad built since 1885 carries a gun of greater weight than 68 tons.—*Engineer.*

Broke her Shaft.—The Dutch steamer *Schiedam*, from Rotterdam for New York and Baltimore, recently broke her shaft at sea.

At six o'clock on the morning of January 28 all hands on board were startled by a tremendous crash, and it was at once surmised by those about deck that the shaft had broken. When the crash occurred the vessel shivered from stem to stern, and no one on board doubted that the propeller had struck something, and that this caused the breaking of the shaft.

The engineers worked four days in making repairs to the shaft, and finally so patched it up that the steamer was able to proceed under steam at the rate of seven or eight miles an hour, but there was always great danger of the shaft giving out again.

During the four days the repairing was being done a hurricane prevailed, and at times the steamer was unmanageable, her spread of canvas not being sufficiently large to enable her to be handled. The hurricane was so severe that she could not spread all her sails, for had she done so they would have been blown to pieces.

After steaming for thirty-six hours after the repairs had been made, the fastenings parted, and the *Schiedam* was again helpless. The engineers worked steadily for twelve hours in patching up the break, and then the engines were started. The shaft had made but comparatively few revolutions when it again parted. This time it so badly damaged one of the trusses that further repairs were impossible. All the sail possible was set and the steamer turned about to make for Queenstown.

Her condition was reported in Queenstown, and tugs were sent out and towed her into that port.

A Combination Tank Steamer.—A steamer of a new and very interesting type has been built recently for Samuels & Company, of London. The vessel is named the *Murex*, and has been constructed especially for the transportation of petroleum, in a manner similar to all tank steamers. The novelty lies in the fact that the vessel can receive the most delicate goods, even cereals, as soon as the liquid cargo has been discharged. It measures about 350 ft. in length, and is provided with 10 tanks, five on each side, and these two groups are separated by a longitudinal partition formed by an extension of the keel into the hold. The tanks extend from the bottom of the hold up to about the water line.

This special construction is separated from the forecastle, where the quarters for the crew are located, and from the stern, where the machinery, boilers, and officers' quarters are placed, by two strong partitions about three feet apart at each end, the space between being kept full of water. The result is that the oil tanks are thoroughly isolated from the bow and stern quarters of the ship.

Openings on the port and starboard permit the steamer to be rapidly loaded to the hatches with mineral oil, and a powerful pump insures the rapid delivery of the 2,500 tons of oil which the *Murex* can carry. This last operation can be accomplished in 24 hours.

The question now arises as to how these tanks can be cleaned, impregnated as they are with oil, and how they are to be made fit to receive a cargo of another character. A very powerful blower sends a great volume of air in a rapid current into the tanks, which are put in communication with each other by openings in the partition walls, made for the purpose. This thoroughly dries the walls, and their disinfection is afterward assured by the introduction of a vapor especially prepared for the purpose, whose composition is kept secret and which absolutely removes every trace and odor of the liquid.

The innovation is a valuable one, for by it the *Murex* can always take on a return cargo from the port to which it may have carried one of petroleum. For example, she recently carried a cargo of oil to India and returned with one of rice.

AMERICAN AND ENGLISH LOCOMOTIVES.

The two folded plates with this number of the Journal show respectively the system of framing for the two locomotives which are the subjects of this series of articles. They represent, too, distinguishing features of English and American practice. The plate frame is, we believe, universally used on English locomotives, and is not used at all in this country; and the reverse is true of the "bar" frame. There has been a great deal of discussion of the practice in the two countries—or, perhaps, if we said *vituperation* it would describe better what has been written and said about it.

It has been argued, in favor of plate-frames, that they are stiffer vertically and more flexible laterally than bar frames, which is no doubt true. They also have the advantage that they permit of a wider fire-box being placed between them. It will be seen that the outside width of Mr. Adams' fire-box is 46½ in., whereas the fire-boxes of American locomotives, when placed *between* the frames, are not more than from 42 in. to 43 in. wide. This argument has no force, however, when the fire-box is placed entirely above the frames—as in Mr. Buchanan's engine—which is now a very common practice in this country. It may be urged as an objection to this that it requires the boiler to be placed very high, and the fire-box cannot, under these conditions, be as deep as it is when it is placed between the frames.

It has also been said of plate frames that there is less machine work required on them, and consequently they cost less. The evidence with reference to this point is not conclusive, however, and will be referred to further on.

In favor of bar frames it is said (1) that they do not obstruct the view of and access to the internal parts of an engine as much as plate frames do; (2) that no deficiency in their vertical strength has ever been experienced; (3) that solid bars have much greater capacity for resisting an endwise concussion, and, therefore, they will resist collisions better than plate frames; (4) that after being planed and machined over their whole surface, they are easier fitted to an engine than plates are which have not true surfaces; (5) bar frames being made in two parts, which are fastened together to to the other parts of the engine by bolts, they are easier to remove and repair or replace than a plate frame like that shown in the engraving, which is rivetted. In case of a front collision, which would bend or break the front end of a plate frame, it would be necessary to take down the whole of the one frame which was injured. To do this the rivets in the stay plates must be cut off, which takes much time and labor, whereas an American frame, being fastened by bolts alone, they or their nuts can easily be unscrewed without injury to them, and they can be used again. If the front end only of the frame is injured it can be taken down and repaired or replaced without disturbing the back portion. Conversely the same thing is true in case the back end of the frame is dam-

aged and the front end uninjured. We are speaking, perhaps, without adequate knowledge in saying that it seems doubtful whether, if a plate frame on one side was damaged to such an extent as to require renewal, a new plate could be fitted in place of the injured one without taking down the uninjured one on the opposite side. With American frames one side can easily be replaced without disturbing the other.

Regarding the relative amount of machine work on the two kinds of frames, it may be said that the engravings of the English frame show that the axle-box guides are bolted to the frames. As stated in Mr. Adams' specifications, "the stay-plates are to be planed to the exact width required, and securely *rivetted* to the frames by cold rivets." This method of construction requires a large number of bolts and rivets in the frames. The drawing of those for the English engine shows that there are no less than 666 holes in the two frames and in the front and tail braces or stay-plates. Each of these holes, with a very few exceptions, must have a bolt or rivet fitted into it. A pair of American frames with the front and tail braces has only 184 holes, so that the number of bolts and rivets to be fitted in the two kinds of frames is in proportion to the number of holes. At present we have not the requisite data to be able to compare the relative cost of drilling or punching the holes and fitting bolts and rivets to them with that of planing and slotting American frames.

The following are the builders' specifications for the frames of the English and American locomotives:

SPECIFICATIONS FOR FRAMES FOR AN ENGLISH EXPRESS PASSENGER LOCOMOTIVE FOR THE LONDON & SOUTHWESTERN RAILWAY.

The frames and frame stay-plates to be made of the best mild Bessemer or Siemens-Martin steel, supplied by makers approved by the Railway Company's Locomotive Superintendent, and of the exact dimensions, both as regards form and thickness, as given on the drawings.

Quality.—The quality of the material to be that generally known as mild-steel plate, and to be free from silicon, sulphur, or phosphorus. The ultimate tensile strain that the plates will stand to be not less than 24 nor more than 30 tons per square inch, with an extension of not less than 23 per cent. in 10 in.

Manufacture.—All plates, whether made by the Bessemer or Siemens-Martin process, to be made in the most approved manner from ingots hammered on all sides, and when reheated to be rolled truly to a uniform thickness. Both sides to be perfectly clean and free from pitting, roll marks, scale, dirt, overlapping, or other defects. Each plate to be taken from the rolls at a full red heat and allowed to cool gradually on a flat surface. Each plate is to be sheared to the dimensions given, and in no case to be sent out before being levelled sufficiently true for machining. All plates that are wavy or buckled or in any way defective will be rejected, and must be replaced by the makers, free of cost. The maker's name and date of manufacture must be legibly stamped on every plate, and not nearer the edges than 9 in.

A sample or test plate at least two feet square must be sent in by the maker as a sample of what will be supplied in the plates to be made under this contract, together with a complete analysis of the same. This test plate is to be ⅞ in. in thickness, and from it pieces will be taken for proving in the following manner:

Test.—A piece 6 in. long will be bent over cold until the ends meet each other closely, and no fracture or sign of failure is to be observable in the heel of the bend. Pieces 3 in. wide will also be taken and a ⅞-in. hole punched through same, which shall stand being drifted cold by taper drifts until it reaches 1¼ in. in diameter without the edges fraying or showing signs of fracture.

Samples or shearings from the plates must be tested in the presence of the Railway Company's Locomotive Superintendent or his Inspector, on the premises of the maker whenever desired.

All the plates are to be perfectly level and straight throughout and marked from one template. All holes are to be drilled and rimered out to the exact sizes given, and each bolt and rivet must be turned to gauge, and fitted into its place, a good driving fit. When the frames and cylinders are bolted together, and before the boiler, wheels and axles are put in their places, the accuracy of the work must be tested by diagonal, transverse and longitudinal measurement.

The frames are to be placed at a distance of 3 ft. 11½ in. apart, and to be stayed at the leading end, in front of the driving-wheels and in front of the fire-box, by steel plates and angle irons, and by a cast-iron foot-plate at the trailing end; the steel plate stays to be planed to the exact width required and securely riveted to the frames by cold rivets. At the leading end a steel casting with suitable flanges is to be riveted to the frames at bottom with ⅞-in. rivets pitched zig-zag, and this casting is to be provided with a boss for carrying the bogie center-pin. This boss to be accurately turned, and to be planed on the bottom side to suit the bogie cross-slide. This casting must be perfectly square with the frames. The driving-wheels are to be placed 1 ft. 5 in. in front of the fire-box. The driving and trailing axle-box guides to be provided with adjustable wedges having a taper of 1 in 10, as shown, guide and wedge to be of the very best cast steel, supplied by makers to be approved by the Railway Company's Locomotive Superintendent. The top and sides are to be in one piece, free from honeycomb and all other defects, and the flanges are to be planed all over and fitted to template; they are to be fastened to the frame with bolts 1 in. in diameter, accurately turned and driven tight in the holes. The horn-stays are to be attached to the guides as shown on drawing. The frames must be finished with a good smooth surface 1 in. thick, and the axle-box guides must be free from cross-winding and square with the engine in all directions. The rubbing plate on back end of frame for the intermediate buffer is to be of wrought iron case hardened.

SPECIFICATIONS FOR FRAMES FOR AN AMERICAN EXPRESS PASSENGER LOCOMOTIVE BUILT BY THE SCHENECTADY LOCOMOTIVE WORKS.

Of best hammered iron, main frame in one section, with braces welded in. Forward section securely bolted and keyed to the main frame. Pedestals protected from wear by cast-iron shoes and wedges, and locked together at bottom by a bolt through cast-iron thimbles. Width of frame, 4 in.

Whatever may be thought of the frames of the two engines, it must be admitted that the specifications of those made by the American builders are the simplest; but it may be questioned whether, in this instance, simplicity is a merit.

The subject of the relative advantages of English and American frames is now open for discussion, and we will be glad to receive contributions relating thereto from either side of the Atlantic.

THE AMMEN RAM "KATAHDIN."

THIS vessel, which is the first war ship ever built having no means of offense except her power to ram an enemy, was launched by the Bath Iron Works at Bath, Me., on February 4. Our full-page engraving represents her as she will appear when completed, and the small sectional views show the general features of her construction. The following description of her is taken from the New York *Herald*:

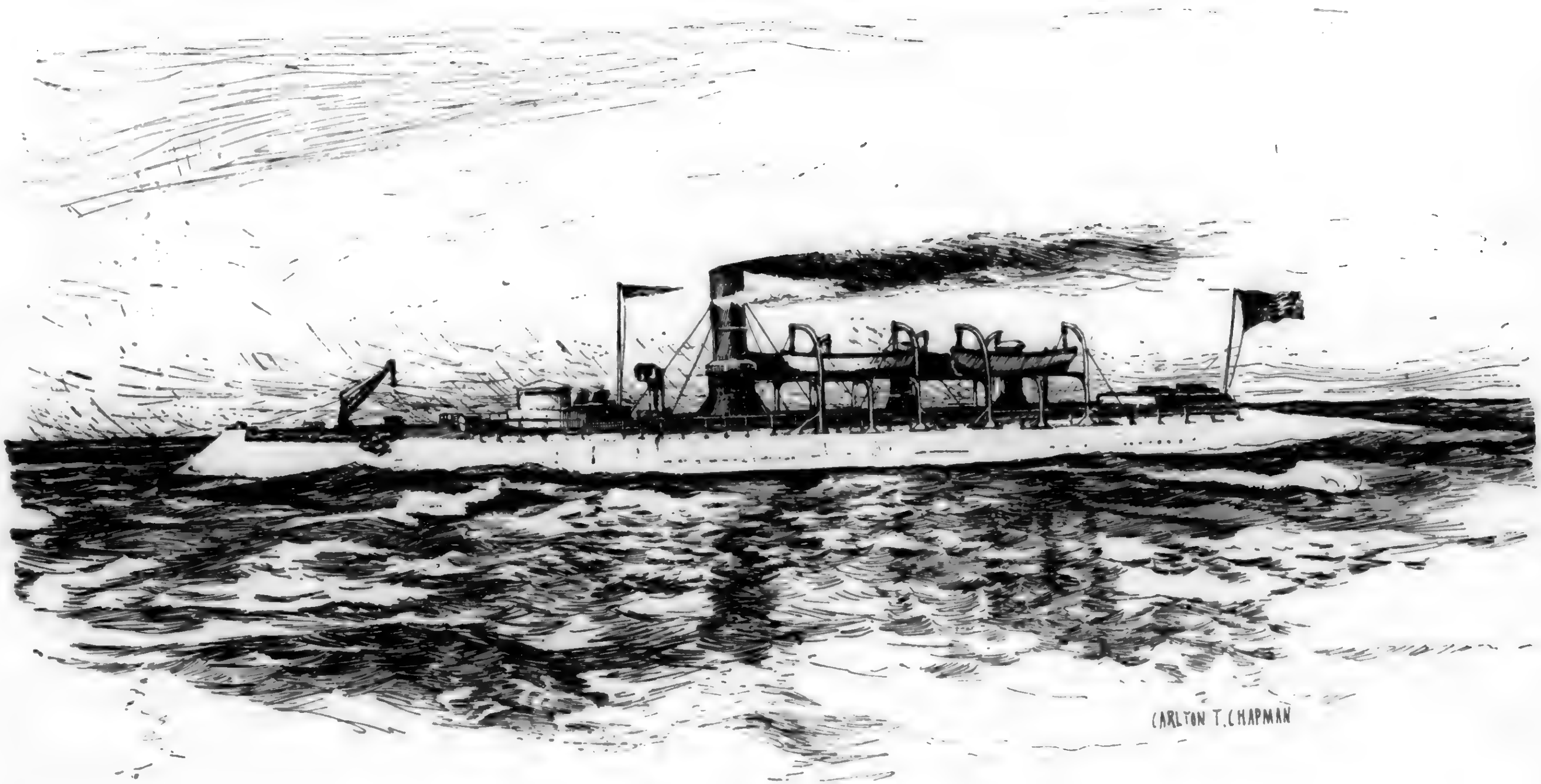
"Of course she is an experiment, and doubtless many improvements would be made if another similar craft were to be designed; but for the present the United States possesses in this ship a unique type.

"To Rear Admiral Daniel Ammen belongs the credit for her general design. He believes that in the excitement of battle such a craft, accompanying and keeping under the protection of battle ships, could dash out against the heaviest armorclad afloat and give a fatal blow to the enemy before the latter's guns could seriously injure the ram. It is, of course, understood that the ram is an auxiliary to the ships in the first line. The *Katahdin* could not hope to attack cruisers, for she is designed for a speed of only seventeen knots, and most cruisers could keep out of her way.

"It was hoped by most navy officers that this craft would be called the *Ammen*, after the distinguished officer to whom she is indebted for her existence; but the demands of Senator Hale, it is said, secured for her the name by which she was christened.

DESCRIPTION OF THE RAM.

"Congress, by act of March 2, 1889, authorized the construction of a twin-screw, armor-plated harbor defense ram upon the design of Rear-Admiral Daniel Ammen, United States Navy, the design being based upon his experience with and defense against rams in the war of the Rebellion. The plans were made in the Bureau of Construction and Repair under supervision of Chief Constructor T. D. Wilson, United States Navy, in consultation with Admiral Ammen. The machinery was designed in the Bureau of Steam Engineering, supervised by Chief Engineer G. W. Melville, Engineer-in-Chief, United States Navy. The time fixed for opening the bids for the construction of the vessel at the Navy Department was December 20, 1890. There was only one bidder—the Bath Iron Works, of Bath, Me.—and on January 28, 1891, the contract was awarded to this company to build and equip the vessel

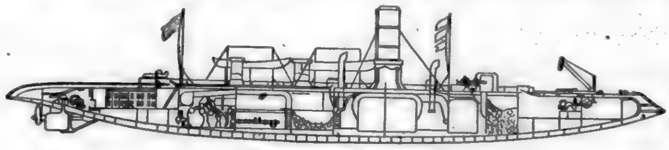


THE AMMEN RAM "KATAHDIN."

and machinery and place the armor for $930,000, to be completed in eighteen months.

"On March 27, 1891, the Department approved the proposition of the contractors to lengthen the vessel 8 ft., the corresponding increase in the displacement—133 tons—being utilized in increasing the coal supply and providing a battery of four 6-pdr. rapid-fire guns for defense against torpedo-boat attack, the original design having no battery whatever. The type and size of the boilers were also modified.

"The final dimensions of the vessel are as follows: Length over all, 251 ft.; length on the normal water-line, 250 ft. 2 in.; breadth, extreme, 43 ft. 5 in., and on the water-line, 41 ft. 6 in. The total depth from the base to the crown of the deck



LONGITUDINAL SECTION.

amidships is 21 ft., and the normal draft of water is 15 ft., the corresponding displacement being 2,155 tons.

"The lower portion of the hull is dish-shaped up to a sharp knuckle which runs all around the vessel 6 in. below the normal water-line, the angle of the knuckle amidship being about 90°. Above this knuckle the shape of the hull is a circular arc, with a radius amidships of 39 ft., rising from 6 in. below to 6 ft. above the normal water line. This curved deck is to be armor plated throughout, the thickness of the armor tapering from 6 in. at the knuckle to 2 in. at the crown of deck.

"Above this deck will rise only a conning tower 18 in. thick, a smoke-stack and ventilator (the lower portions of which will be protected by 6 in. of armor), two light barbettes, within which the guns will be mounted and skid beams carrying four boats.

THE ARMOR BELT AND COMPARTMENTS.

"Below the knuckle will extend an armor belt 5 ft. deep, one-half being 6 in. thick and the remainder 3 in. A continuous water-tight inner bottom 2 ft. from the outer skin is carried nearly the whole length of the vessel, and up to the armor shelf on each side, being divided into three water-tight portions on each side of the keel longitudinally, and these further cross-divided by 13 water-tight transverse frames, thus dividing the bottom into 72 water-tight compartments. The interior of the hull is further subdivided by water-tight bulkheads, both longitudinally and transverse.

"Admiral Ammen originally wished to have a spur at the bow, so arranged that on ramming an enemy the spur would break off without injury to the rest of the hull. This has not been found practicable; and the spur—a steel casting weighing 10.8 tons—is a prolongation of the stem, to which all the forward plating is attached.

"The propelling machinery will consist of two sets of triple-expansion engines, the cylinders being respectively 25, 36 and 56 in. in diameter, the stroke of pistons being 36 in.

THE INDICATED HORSE POWER.

"The estimated maximum horse-power, with 150 revolutions per minute, is 4,800. There are two screw propellers, each 10 ft. 6 in. in diameter and 15 ft. 2 in. pitch. There are two double-ended and one single-ended cylindrical Scotch boilers, 13 ft. 6 in. in diameter, having nine furnaces each 42 in. in diameter. The total grate surface is 354 ft., and the heating surface is 12,150 sq. ft. The coal bunker capacity is 237 tons, the normal supply being 175 tons. Provision is made for carrying about 200 tons of water ballast in the double bottom, which will sink the vessel in action so that the knuckle will be about one foot below the water-line.

"The estimated speed with full power is 17 knots per hour, and this must be attained to render the vessel acceptable under the contract.

"The quarters for officers and crew are all within the armored hull, and there will be fitted complete systems of electric lighting, artificial ventilation and drainage.

"The ram will be manned by 7 officers and 91 men, of whom 71 will be in the engineer's department."

NAVAL ARCHITECT C. N. HANSCOM,

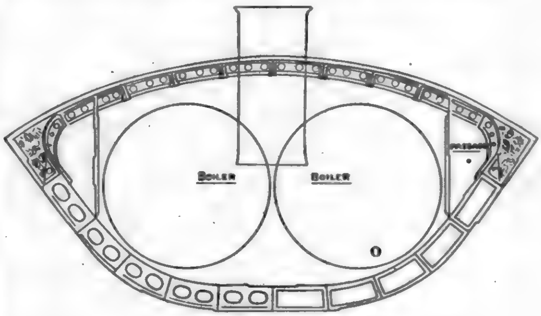
the Superintendent of the shipyard at the Bath Iron Works, is a comparatively young man, but has had an unusual amount of experience in war-ship building, and the ram constructed under his guidance will probably add much credit to an active life.

HOME NAVAL NOTES.

Transfer Boats as War ships.—Two of three gigantic ferry-boats for the North Michigan Railroad have been launched, and they are so constructed that they can be converted into war-ships at 24 hours' notice. They are of great strength and carry 24 freight cars each from Kewaunee, Wis., to Frankfort, Mich., across Lake Michigan, a distance of 60 miles, without breaking bulk. The *Ann Arbor* is capable of carrying a battery of twelve 6 in. 5 ton breech loading rifles.

Cruiser "Concord."—The Chief Engineer of this ship has been unable to return to active duty, owing to physical disabilities. It is said that much sickness and breaking down has occurred in the engineer's force of this ship, which is attributed to the extraordinary heat temperatures in her engine and fire rooms. The temperature of 165° Fahrenheit has been recorded aboard this ship, and the sickness which occurred was due directly to the strain thus imposed. Cramped fire room space and faulty ventilation appear to be the causes which have led to the defects existing aboard the *Concord*.

The "Destroyer" to be Tested at Newport.—The experiments in which the *Destroyer* is to figure at the Newport Torpedo Station are to determine the relative value of various steel nets, such as are now used in defending iron-clads from torpedo attack. None of the warships of the United States is provided as yet with net defenses. The result of the coming experiments will enable the Bureau of Ordnance of the Navy Department to select some one good type, or combination of types of nets. The gun which will be employed aboard the *Destroyer* is one of recent make, and, it is said, possesses numerous advantages over the original Ericsson submarine weapon.



CROSS-SECTION.

New Armor Specifications.—The new specifications for armor under the contract for 7,000 tons of this material have been issued from the Naval Bureau of Ordnance. The contractors will find the requirements more exacting than the specifications of 1887, under which the present deliveries of armor plate are being made. The increase in the requirements is the result of the tests of armor during the past three years, in which was developed a nickel alloy and a face-hardening process. The new specifications have been revised to embrace the new conditions, which demanded stricter acceptance tests and closer inspections.

Dry-Docks at Brooklyn and Puget Sound to be Lengthened.—Secretary Tracy has approved a report of the Board of Navy Officers on the dry-dock at the Brooklyn Navy Yard that the dock could be lengthened 70 ft. on the bottom, and that this additional length would be sufficient for all the needs of the service. The main object in lengthening the dock beyond the dimensions originally planned was to accommodate such ships as the *City of New York*.

The timber dock at the Puget Sound Station will also be lengthened by 50 ft., so as to make the total length, when completed, 650 ft., the same as the dock at Brooklyn. The Navy will then have two docks, which will accommodate any ship afloat in the Atlantic or the Pacific.

The "Oregon's" Armor Plating.—The *Oregon's* 14-in. plate is the heaviest piece of armor plating as yet put up in the Unit-

ed States for test. It will be attacked by a 10-in. gun placed not more than 50 ft. from the front of the armor. The plate will be fired at until destroyed. The attack will commence at low initial velocities, and these velocities will be increased with each succeeding shot. So long as the plate holds together, little fear is felt that any of the shells will reach the wood backing. In some quarters the 14-in. plate to be tried is not deemed as good a plate in quality as some of the plates built previously on the Harvey process. The present plate, it is thought, has too high carbon and may develop cracks at a too early period of the attack.

Electricity in the Navy.—Naval officers who come up for examination hereafter must be prepared to answer any questions put to them on electrical matters. Four ensigns who were before the Examining Board recently refused to answer the questions which were propounded by the Board, and the objections were sustained. It will require an official order from the Secretary to warn other officers that they must be ready to respond to queries on the important subject which has of late years entered so fully into the work of naval officers, afloat or ashore.

The Government is spending a great deal of money to teach the cadets at Annapolis the theory and application of electricity, and it is putting electrical machinery in every ship that is building.

New Ship of the Monitor Type.—It is said that the Navy Department has under consideration designs for a new ship of the monitor type, exclusively for harbor defense.

The plans contemplate a vessel exclusively for harbor defense and of the monitor type. The ship would have very little freeboard, which would be covered with armor. It would be fitted with a turtle-back deck to deflect projectiles. Nothing would appear above the deck except the smoke-stack and the amply protected conning tower. There would be no turrets to add weight to the vessel, and the guns would be kept below decks, be elevated for firing, and then disappear.

The designer of this ship, which is termed a floating battery, is Lewis Nixon, late a naval constructor in the Navy, and now connected with the Cramp concern in Philadelphia. The idea of doing away with the turret strikes the naval experts favorably. The only feature which has an element of doubt is the disappearing carriage.—*New York Times.*

Trial of the Cruiser "Bancroft."—This vessel, it is said, was designed for a speed of only 12 knots per hour, and the mean speed of 14.4 knots obtained during its trial trip is attributed directly to excellence of engine workmanship and good firing.

The board members were particularly struck, they say, by the absence of all leaking from the stuffing boxes. The fit of the piston rods was apparently closer than in the case of any of the new machinery built for the Navy. When the builders were questioned on this point they stated that the piston rods were first turned off and then ground down to a fit on emery wheels. To obtain the tight fit, the Moores spent $5,000 additional money in labor and tools.

Throughout the whole of the four hours' run there was not the slightest indication of heating, and at no time during the trial was it found necessary to turn water on the bearings.

The builders of the *Bancroft* state that the vessel cost in labor and material $20,000 over and above the contract price. The latter was in the neighborhood of $240,000. The bonus obtained as a result of the extra speed developed will enable the contractors to make a slight profit. The contract has at least had the effect of developing the ship plant of the Elizabethport firm, and that, too, at no loss to the firm.—*New York Times.*

The "Amphitrite's" Barbettes Completed.—The barbettes for the new double-turreted monitor *Amphitrite* are completed at the Bethlehem Iron Works. The *Amphitrite* is at present at the Norfolk Navy Yard, where she is being supplied with turrets for the protection of a four 10-in. breech-loading rifle battery that has been designed for her. Her turret armor consists of curved steel plates 11½ in. thick. This is the same thickness of metal that has been allowed to the turrets of the double-turreted monitor *Miantonomoh*, now at the Brooklyn Navy Yard.

The barbettes just turned out will be shipped in the course of a few days to the Norfolk Navy Yard and there assembled aboard the vessel. The weight of the two guns in each turret will be 50 tons.

The *Amphitrite*, to which the newly made barbettes will be supplied, is one of the five monitors for which sufficient money to complete their building was obtained during the administration of Secretary of the Navy Whitney. Of the five, *Miantonomoh*, *Monadnock*, *Terror*, *Puritan*, and *Amphitrite*, the last named will probably have no superior in the lot as a fighting ship, except, perhaps, the *Puritan*. The *Amphitrite* is a vessel of 3,815 tons, has a length of 249 ft., a beam of 60 ft., and draws 14 ft. 8 in. of water. Her armor on the hull has a thickness of 7 in. The vessel's speed will be 12 knots per hour. On a less coal-carrying capacity than that of the *Miantonomoh* it is calculated that her radius of action will be fully equal to what is credited to the latter. The *Miantonomoh*, it is claimed, can steam 1,800 knots on 330 tons of coal.

The completion of the barbettes for the *Amphitrite* will enable that ship to be commissioned during the present year. —*New York Times.*

Lack of Torpedoes.—With the exception of the torpedo boat *Cushing* there is not a torpedo afloat on any of the war ships of the United States. To date of December 31, 1891, England had afloat and in reserve no less than 2,874 Whitehead torpedoes.

The United States, in taking up the Howell torpedo, which is now handled by the Hotchkiss Ordnance Company, is also preparing to use Whitehead weapons. The little *Cushing* is provided, for instance, with a Whitehead torpedo armament for her bow tube and Howell torpedoes for use in the deck turn-table tubes. The Whitehead torpedoes ordered for the United States are being manufactured by E. W. Bliss & Co., of Brooklyn. The Howell torpedoes are being manufactured at the Hotchkiss Ordnance Shops in Providence.

The Howell torpedo passed through its successful tests over a year ago, and on one occasion, when firing from a stationary deck gun 7 ft. above water, it attained to a range of 400 yards. The average speed of nine runs was 22½ knots, and the deviations, average of ten runs, were: Vertical, 2,764 ft.; horizontal, 21 ft.

The latest pattern of the Whitehead, known as the Woolwich design, is an 18-in. diameter projectile fitted with a bluff head, and intended especially for use with under-water discharge. A torpedo of the Woolwich pattern carries a charge of 250 lbs. of gun cotton. Successful trials with one of the latter Whiteheads record a speed of 30 knots for 700 yards, and 32 knots for 437 yards. The length of the 18-in. weapon is 16.4 ft., its weight 1,100 lbs. The explosive charge consists of 220 lbs. of gun cotton.

France and Austria have lately ordered 18-in. Whiteheads which are to have a speed of 29¼ knots for 875 yards, and carry 198 lbs. of explosive. In the British Navy the 18-in. Whitehead is fitted to the larger type of war ship, and the 14-in. to the smaller type.

The new Woolwich torpedo possesses several improvements over the 1885 Whitehead; one is in the valve regulating the speed of the propellers before and after immersion, and another is in the insertion of a positive screw valve between the air and the machinery compartments, to confine the air absolutely until a short time before firing. The power of the large torpedoes, with their length and weight, is now such that they are not deflected, even in a heavy sea. The highest speed stated to have been yet attained for a short distance is 34 knots.

It is calculated that fully a year will elapse before the new ships of the United States Navy can count upon receiving a torpedo outfit.

WAR SHIPS UNDER CONSTRUCTION.

There are at present 27 vessels of war authorized or building for the United States Navy which have yet to fly for the first time a commission pennant. All but two of the 27 ships are in process of construction. The two ships authorized but not yet ordered built are the dynamite cruiser No. 2 and the torpedo-gunboat cruiser.

The vessels under construction and their probable time of readiness, from present indications, follow:

Amphitrite, double-turreted monitor, completing at Norfolk Navy Yard. Can be made ready for service in 12 months.

Puritan, barbette battle ship, at Brooklyn Navy Yard. Requires 18 months' work at present rate.

Monadnock, double-turreted monitor, completing at Mare Island Navy Yard. Requires 18 months more.

Terror, double-turreted monitor, completing at Brooklyn Navy Yard. Can be made ready for service in nine months.

Texas, coast-defense battle ship, completing at Norfolk Navy Yard. Can be made ready for service in 12 months.

Maine, armored cruiser, at Brooklyn Navy Yard. She is ready for service save for the placing of her armor. The

Maine will probably be delayed fully 12 months awaiting this armor.

Brooklyn, armored cruiser, awarded to the Cramps of Philadelphia to build. It will be fully three years before the ship is found in commission.

New York, armored cruiser, fitting out at the Cramps' yard, Philadelphia, for service. The *New York* is booked to participate in the Columbian naval review as flagship. She is reported as able, probably, to go into commission by March 31.

Katahdin, harbor defense ram, completing at the yards of the Bath Iron Works, Bath, Me. Will be ready for service in 12 months.

Massachusetts, coast-line battle ship, building at the Cramps' establishment, Philadelphia, will be ready for launching by May 1. The *Massachusetts* will probably require two years' work before being ready for commissioning.

Indiana, coast-line battle ship, building at the Cramps' establishment, and will be launched early in March. She will take 20 months' additional work.

Oregon, coast-line battle ship, building at the Union Iron Works, San Francisco. The *Oregon* will not be ready for service inside of 30 months.

Iowa, seagoing battle ship, will be built by the Cramps of Philadelphia. She will not be ready for commissioning in less than three years.

Olympia, cruiser, completing at Union Iron Works, San Francisco, will be ready for commissioning in 12 months.

Cincinnati, cruiser, completing at Brooklyn Navy Yard, will be ready for commissioning in 12 months.

Raleigh, same as *Cincinnati*, building at the Norfolk Navy Yard.

Montgomery, cruiser, completing at Columbian Iron Works, Baltimore. She will be commissioned prior to May 1.

Detroit, cruiser, same as *Montgomery*.

Marblehead, cruiser, completing at Harrison Loring's Yard, South Boston, will be ready for commissioning by September 1.

Columbia, cruiser, building at the Cramps' establishment, will be ready for service in 18 months.

Minneapolis, cruiser, building at the Cramps' establishment, will be ready for service in 20 months.

Machias, gunboat, completing at the Bath Iron Works, will be commissioned by May 1.

Castine, gunboat, building at Bath Iron Works, will be ready for commissioning by July 1.

Torpedo Boat No. 2, building at Iowa Iron Works, Dubuque, Iowa, will be ready for service by September 1.

Bancroft, practice cruiser, completing at S. L. Moore's yard, Elizabethport, N. J. The *Bancroft* has undergone her official trial for acceptance, and will be ready for commissioning in the course of the next six weeks.—*New York Times*.

NEW SHIPS FOR THE LAKES.

Mr. John Craig, President of the Craig Ship-building Company, of Toledo, O., recently reported the following conditions existing in the ship yards on the lakes:

"Nearly every yard on the lake system," he said, "is doing about all the work it can handle. At Bay City, Mich., the Wheelers are building two steel steamers, which are designed to be the largest ships ever seen on the great lakes. They are for the firm of Whitney, Avery & Hawgood. The keel length of each ship will be 360 ft. It is noteworthy that the engines of the two ships will be placed in the center of the vessels, instead of well aft, as in the case of the majority of lake steamers. In addition, the Wheelers are building three large modern steamers and several tugs.

"At Cleveland, the Globe Ship-building Company is building, in addition to freight steamers, two ships for the Great Northern Steamship Company, which, I understand, are designed to make the run between Buffalo and Duluth in fifty hours. So far as I could glean in recent conversation with fellow lake men, the opinion is held that the two boats will consume in fuel and repairs all money that it is possible to make out of them. The frames for one of the ships are now up and are nearly ready for plating. The Globe Ship-building Company is not understood among lake men to be guaranteeing speed. The company is merely building the ships as called for by the designs of Miers Coryell, the constructor in charge.

"The Cleveland Ship-building Company is building ten large steel steamers. At Detroit the Detroit Dry Dock Company is building a magnificent freight steamer for service in the Mackinaw Straits. The new vessel is designed to be an ice fighter. She will have a run of twelve miles to make, and this she will endeavor to do the year round. She will carry freight cars on rails laid on deck, and thus obviate breaking bulk. She is fitted with fore and stern screws operated on independent shafts and by independent engines. The bow screw is meant for service in crushing and breaking ice. The ice problem is the only difficult one which has to be solved in the Mackinaw Straits, and the problem becomes a momentous one in the winter season. The new ice fighter will cost about $350,000.

"At Chicago, the Chicago Ship-building Company is busy on a couple of freight steamers. The Union Dry Dock Company, of Buffalo, is building a fast freight steamer for the Erie Railroad for service between Toledo and Buffalo. This freight steamer will break freight bulk at each end of the route. Several tugs and fire boats are building at Buffalo. David Bell, of that place, is building a revenue steamer for the Government for service at the port of Chicago."

Mr. Craig was asked what general impression prevailed as to the causes of the disasters to the *Western Reserve* and the *Gilcher*, two large freight steamers lost in Lake Erie last fall.

"The *Western Reserve*," he said, "undoubtedly broke in two. This belief has become the generally accepted one. There is not, however, the same unanimity of opinion concerning the cause of the loss of the *Gilcher*. Personally I am inclined to think that the latter ship struck a derelict. The *Western Reserve* undoubtedly received, in the course of her construction, some faulty hull material."

"What precautions have been taken," Mr. Craig was asked, "on the part of lake men to guard against future faulty construction?"

"The matter has been under consideration for some time by the Lake Owners' Association, the Carriers' Association and the Inland Lloyds. It has been decided that all ships now on the lakes shall be examined and standardized by representatives of the Bureau Veritas, the French Lloyds, and the standardization made by them shall be accepted by the associations. The work of inspection is now in progress, and is under the general charge of Captain F. D. Herriman, the Chief Inspector of the Bureau Veritas. As soon as this authority passes upon a ship the vessel is open to classification in the Inland Lloyds. On the whole the effect of last year's disasters will tend to the building of abler vessels and ships having at least closer attention paid to their hull material.

"The general outlook for the coming year promises to be better than for many years. Lake ships still continue to pay about 25 per cent. upon the capital invested in them, and so long as this continues ship-building in the Northwest will prosper. I well remember when grain freight paid as high as 32 cents per bushel from Milwaukee to Buffalo, but that was at a time when lake tonnage rarely exceeded in carrying capacity 500 tons per ship. Now we find the freight rates down to two cents per bushel, and ships engaged in the carrying trade capable of handling 2,500 tons and more of cargo. As the rates have decreased, carrying capacity has increased, and, as a consequence, the general profits are to-day about equal to what they were in former days, when rates were so extraordinarily high.

"All new vessels of over 2,000 tons burden are, as a rule, being built of steel. Smaller vessels continue to be built of wood. Steel is, however, becoming the popular material, and I think will prove the more economical choice in the long run. As yet we have not had sufficient experience with steel ships to furnish any accurate data on this subject."

Mr. Craig is the designer and builder of the two novel freight steamers, *Ann Arbor No.* 1 and *Ann Arbor No.* 2, constructed recently for the Toledo, Ann Arbor & North Michigan Railroad, and now engaged in carrying freight cars across Lake Michigan the year round. The two boats are deemed by Government inspectors to be the strongest vessels on the lakes. Mr. Craig says that the two steamers have proved beyond question their ability to keep open communication on Lake Michigan in the most severe weather.

Mr. Craig adds that MacDougal, of West Superior, is building no less than five whaleback steamers. The type is still unpopular, "but somehow our lake men are being forced to take them up," Mr. Craig says.

In addition to the above we publish extracts from a private letter recently received from West Bay City, Mich., regarding the ship-building interests at that place, with data concerning other work along the shores of the great lakes.

"There was a most successful launch on February 4 of a big steel freighter for Captain John Mitchell and others of Cleveland. The feature of the launch was the necessity of cutting sufficient ice out of the river to let her drop in. The ice was about 18 in. thick. She slid in about 5 P.M., and her dimensions are as follows: Length of keel, 328 ft.; over all, 345 ft.;

beams, molded, 41 ft. 6 in.; extreme, 42 ft. 6 in.; depth, 24 ft.; three pole-masts, fore-and-aft schooner rig; triple-expansion engines 20 in., 32½ in., 55 in. × 42 in. stroke; boilers, 2 in number, cylindrical, 13 ft. diameter, 12 ft. 8 in. long, 160 lbs.; steam propeller, 12 ft. 6 in. diameter, 14 ft. 6 in. pitch.

"The very severe weather experienced during the last two months has told a great deal on the work in hand, as the men have been absolutely unable to put in full time on account of the cold. There are now about 1,300 men on the pay-roll, and everything is rushing for all it is worth and as well as the weather permits. There are now 10 vessels in course of construction, and we are not idle. In the machine shop six engines are now building, and we are about the busiest on the lakes, if not the busiest. There are two triple-expansion engines of 23 in., 37 in. and 63 in. × 44 in. stroke; two triple-expansion of 20 in., 32½ in and 55 in. × 42 in. stroke; one triple of 17 in., 28 in. and 47 in. × 44 in. stroke, and a compound engine for a tug of 11 in. and 24 in. × 14 in. stroke; besides the above we are compounding the engines of a small wooden steam barge. Considering that only two or three months have elapsed since really starting in to build our own engines, it says a great deal for the go-ahead policy of F. W. Wheeler & Company.

"The boats are as follows:

"Steamer No. 93, steel, the dimensions of which are given you above. She was launched February 4.

"Steamers Nos. 94 and 95, steel, for Hawgood & Avery, of Cleveland, and D. Whitney, of Detroit, respectively. Length of keel, 360 ft.; over all, 377 ft. 6 in.; beam, molded, 44 ft.; extreme, 45 ft.; depth, molded, 25 ft.; two pole-masts; engines, triple-expansion, 23 in., 37 in. and 63 in. × 44 in. stroke; boilers, 3, cylindrical, 12 ft. 6 in. diameter, 12 ft. 8 in. long, 160 lbs. pressure; propeller, 14 ft. diameter, 16 ft. 6 in. pitch.

"Schooner No. 96, wood, for Colin McLachlan and others, Port Huron, four-masted, fore-and-aft rig. Length of keel, 251 ft.; length over all, 267 ft.; breadth, extreme, 41 ft. 2 in.; depth, molded, 18 ft. ½ in.

"Steamer No. 97, wood, Hawgood & Canfield, Cleveland. Length of keel, 290 ft.; over all, 307 ft.; beam, molded, 41 ft.; extreme, 42 ft.; depth, molded, 23 ft.; only foremast; engines, triple-expansion, 20 in., 32½ in. and 55 in. × 42 in.; boilers, two, cylindrical, 12 ft. 6 in. diameter, 12 ft. 8 in. long, 160 lbs. pressure; propeller, 12 ft. 6 in. diameter, 14 ft. 6 in. pitch.

"Steamer No. 98, wood, Bradley and others, Cleveland. Length of keel, 270 ft.; over all, 284 ft.; beam, 39 ft. 4 in.; depth, molded, 22 ft.; three-masted, fore-and-aft schooner rig; engines, triple-expansion, 17 in., 28 in. and 47 in. × 44 in. stroke; boilers, two, cylindrical, 11 ft. long, 12 ft. diameter, 170 lbs. pressure.

"Schooner No. 99, wood, John Francombe, of Detroit. Length of keel, 201 ft. 8 in.; over all, 209 ft.; beam, molded, 34 ft.; depth, molded, 14 ft. 6 in.; three-masted, fore-and-aft schooner rig.

"Steamer No. 100, steel, building on account. As this is the firm's one hundredth ship, they are going to name her the *Centurion*. Length of keel, 360 ft.; over all, 378 ft.; beam, molded, 44 ft.; extreme, 45 ft.; depth, molded, 26 ft.; two masts (pole); engines, triple-expansion, 23 in., 37½ in. and 63 in. × 44 in. stroke; boilers, three, cylindrical, 12 ft. 6 in. diameter, 12 ft. 8 in. long, 160 lbs. pressure; propeller, 13 ft. 6 in. diameter, 17 ft. pitch. We have made a great departure in adopting the ocean style of craft in steamers Nos. 94, 95 and 100, by placing engines and boilers directly amidships, the only other boats built on the lakes like that being the *Owego* and *Chemung*, designed by George Mallory, and built at Buffalo; they are, however, much smaller than these boats. Since the unfortunate losses of both the *Western Reserve* and the *Gilcher*, every one is trying to lessen the strains to which these long, wide and shallow boats are subjected, and as placing the machinery amidships helps to a great extent, and there seems nothing really to prevent their being placed there, Mr. Wheeler has decided to take the lead and prove to the country that it can be and will be done; our scantlings, although according to the American Shipmasters' Association, are really in excess of both the English Lloyds and the American Shipmasters' Association rules.

"Schooner No. 101, wood, Captain William Forbes and others, Port Huron. Four-masted, fore-and-aft rig; length of keel, 270 ft.; 286 ft. over all; beam, molded, 41 ft.; extreme, 42 ft.; depth, molded, 20 ft.

"Tugboat No. 102, wood, Captain Armstrong, Bay City, for fire service station at Saginaw. Length of keel, 53 ft.; over all, 60 ft.; beam, molded, 15 ft.; depth, 7 ft. 6 in.; engines, F. & A. compound, 11 in. and 24 in. × 14 in. stroke; fire-box boiler, 4 ft. 9 in. diameter, 10 ft. 6 in. long, 100 lbs. pressure. She will be fitted with fire-pumps of great power, and every appliance for speedily quenching flames."

CAR-COUPLER BILL.

We give below the full text of the bill which has passed the Senate, requiring the use of automatic couplers and continuous brakes by the railroad companies of the United States. The bill was passed on the afternoon of February 11 by a vote of 39 to 10.

Section 1. That from and after the first day of January, 1898, it shall be unlawful for any common carrier engaged in inter-State commerce by railroad to use on its line any locomotive engine in moving inter-State traffic not equipped with a power driving-wheel brake and appliances for operating the train-brakes system, or to run any train in such traffic after said date that has not a sufficient number of cars in it so equipped with power or train-brakes, that the engineer on the locomotive drawing such train can control its speed without requiring brakemen to use the common hand-brake for that purpose.

Sec. 2. That on and after the first day of January, 1898, it shall be unlawful for any such common carrier to haul or permit to be hauled or used on its line any car used in moving inter-State traffic not equipped with couplers, coupling automatically by impact, and which can be uncoupled without the necessity of men going between the ends of the cars.

Sec. 3. That when any person, firm, company, or corporation engaged in inter-State commerce by railroads shall equip a sufficient number of its cars so as to comply with the provisions of Section 1 of this act, it may lawfully refuse to receive from connecting lines of road or shippers any cars not equipped sufficiently in accordance with the first section of this act, with such power or train-brakes as will work and readily interchange with the brakes in use on its own cars, as required by this act.

Sec. 4. That from and after the first day of July, 1895, until otherwise ordered by the Inter-State Commerce Commission, it shall be unlawful for any railroad company to use any car in inter-State commerce that is not provided with secure grab-irons or handholds on ends and sides of each car for greater security to men in coupling and uncoupling cars.

Sec. 5. That within 90 days from the passage of this act the American Railway Association is authorized hereby to designate to the Inter-State Commerce Commission the standard height of drawbars for freight cars, measured perpendicular from the level of the tops of the rails to the centers of the drawbars, for each of the several gauges of railroads in use in the United States, and shall fix a maximum variation from such standard height to be allowed between the drawbars of empty and loaded cars. Upon their determination being certified to the Inter-State Commerce Commission, said commission shall at once give notice of the standard fixed upon to all common carriers, owners, or lessees engaged in inter-State commerce in the United States by such means as the commission may deem proper; but should said association fail to determine a standard as above provided, it shall be the duty of the Inter-State Commerce Commission to do so before July 1, 1894, and immediately to give notice thereof as aforesaid, and after July 1, 1895, no cars, either loaded or unloaded, shall be used in inter-State traffic which do not comply with the standard above provided for.

Sec. 6. That any such common carrier using any locomotive engine, running any train, or hauling or permitting to be hauled or used on its line any car in violation of any of the provisions of this act, shall be liable to a penalty of $100 for each and every such violation, to be recovered in a suit or suits to be brought by the United States District Attorney having jurisdiction in the locality where such violation shall have been committed, and it shall be the duty of such District Attorney to bring such suits upon duly verified information being lodged with him of such violation having occurred, and it shall also be the duty of the Inter-State Commerce Commission to lodge with the proper District Attorneys information of any such violations as may come to its knowledge, provided that nothing in the act contained shall apply to four-wheeled cars or to locomotives used in handling such trains.

Sec. 7. That the Inter-State Commerce Commission may, from time to time, upon full hearing and for good cause, extend the period in which any common carrier shall comply with the provisions of this act.

Sec. 8. That any employé of any such common carrier who may be injured by any locomotive, car, or train in use contrary to the provisions of this act, shall not be deemed thereby to have assumed the risk thereby occasioned, although continuing in the employment of such carrier after the unlawful use of such locomotive, car, or train had been brought to his knowledge.

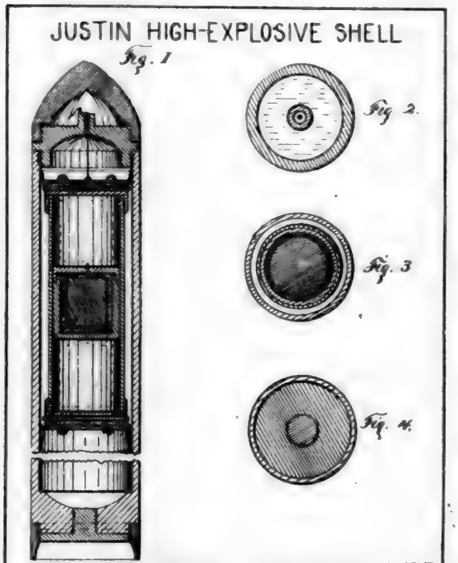
SHELLS WITH HIGH EXPLOSIVES.

(From *Annual No. XI.* of the Office of Naval Intelligence.)

The most important experiments undertaken during the past year by private parties to develop the use of high-explosive projectiles in powder-charged guns have been those of Justin in the United States and Snyder in South Wales.

THE JUSTIN SHELL.

To relieve the shock of discharge, Dr. Justin places his explosive, surrounded by a compressible absorbent, in wooden boxes which are contained in a cylindrical carrier. This carrier is of less diameter and shorter than the body of the shell, and is fitted with leather disks having overturned edges, which are secured on the top and bottom of the carrier by washer heads and rubber relief-disks. A wire holding the carrier in a forward position is broken upon shock of discharge; the body of the shell moving forward, the inertia of the carrier forces it to the rear, compressing the



air behind it. This compressed air forces its way in front of the carrier by passing through ports in the rear leather disks, so that the cushioning effect of the compressed air is regulated by the sizes of these ports. The shell is exploded on impact by either a percussion or a delayed-action fuse. It is shown in figs. 1, 2, 3 and 4.

Dr. Justin ascribes the failures of previous experiments to weakness of the bases of his projectiles.

At Perryville, N. Y., September 1 and 10, 1891, shells were successfully fired from a 5-in. Parrott rifle and an 8-in. Blakely. On December 22, 1891, a shell containing 30 lbs. explosive gelatin was fired with a charge of 30 lbs. brown prismatic powder from a 6-in. Parrott rifle at a bank of earth 75 ft. distant; it penetrated 17 ft. without exploding. Another unfused shell, charged with 8¼ lbs. explosive gelatin, failed to explode on impact when fired at rock 690 ft. distant.

A modified form of shell in which the rear face of the carrier is convex, so as to diminish the rear surface area which tends to rotate the charge with the body of the shell, due to the rifling, and thus decrease friction, was tested June 20, 1892, with the following results:

1. Five shells, each weighing 56¼ lbs., with a charge of 6¼ lbs. explosive gelatin, were fired from a 5¼-in. Parrott gun. Four were fired against a stone precipice, the fifth through a ⅝-in. steel plate and 16 ft. of earth, without exploding.

2. A projectile weighing 60¼ lbs., with a charge of 5 lbs. explosive gelatin, was fired from the 5¼-in. Parrott gun, passed through a ⅝-in. steel plate and was exploded in the butt by delayed-action fuse.

3. Three shots weighing 225 lbs. each, with charge of 34 lbs. explosive gelatin, and three weighing 214 lbs. each, with charge of 36¼ lbs. explosive gelatin, were fired successfully from a 9-in. Blakely gun.

4. A projectile weighing 254 lbs., charged with 30 lbs. explosive gelatin, was fired from a 9-in. Blakely gun; it perforated 3 in. of steel and was exploded in backing by the delayed-action fuse.

A member of the company is quoted as saying that since June, 1891, one hundred 6-in. projectiles, 3 ft. long, have been fired without accident.

THE SNYDER SHELL.

The method employed by Snyder to relieve the shock of discharge is shown in figs. 5 and 6.

The projectile has the usual ogival head, a solid base, and the rear half of its cylinder is turned down to a less diameter than the caliber of the gun. Fitted over its base is a brass cylinder, with solid base and open head, containing a fluted rubber cylinder, which is pierced with about 30 holes. When the discharge occurs the pressure of the powder gases shortens the cylinder, compresses the rubber and contained air which produce the cushioning effect, and bulges the cylinder so that it expands and takes the rifling of the bore of the piece. The base cylinder drops off soon after leaving the muzzle. These projectiles can be used with either rifled or smooth-bore guns.

Experiments were conducted with this system of projectiles at Aberdare, South Wales, October 5, 1891.

Using a 7-in. Blakely muzzle-loading rifle and a 6-in. Armstrong breech-loading rifle, projectiles weighing 229 lbs. and 218 lbs., respectively, containing 10 lbs. of explosive gelatin of 4 per cent. camphor, several rounds were fired with low velocities at 3-in. and 6-in. wrought-iron targets. No accidents nor premature explosions occurred, but the effects on the targets were not very marked, owing, probably, to insufficient delayed action on impact, or to low velocities.

On October 26, 1891, a 7-in. shell, containing a bursting charge of 12½ lbs. of explosive gelatin, was fired through a ¼-in. steel plate and buried itself in a hill 1,200 ft. distant without exploding. Another shell, containing an explosive charge of 7½ lbs. of dry gun-cotton and ¾ lb. of explosive gelatin, was also successfully fired with the usual powder charge.

It being considered doubtful whether these projectiles would safely withstand the pressures developed with high velocities, two rounds were fired on February 1, 1892, all details being conducted in the presence of two retired English army officers. The object of this trial was to give conclusive proof of the safety with which explosive gelatin could be fired in these shells from powder guns.

The gun used was a 6-in. Armstrong breech-loading rifle, and the details of the shots were as follows:

1. Total weight of loaded shell, 78 lbs.; rubber buffer and case, 21 lbs. The charge was 7 lbs. nitro-gelatin. Charge of gun, 50½ lbs. brown prismatic powder; initial velocity, 1,284 foot-seconds. The low velocity was attributed to the damp powder used.

2. Total weight of loaded shell, 76 lbs.; rubber buffer and case, 21 lbs. The charge was 7 lbs. of nitro-gelatin. Charge of gun, 45½ lbs. black prismatic powder; initial velocity, 1,706 foot-seconds. The projectile used had two ring grooves cut in its head to bite when striking at an angle.

Both of these projectiles exploded on impact with a soft bank. Portions of the brass cases, showing rifling impressions, were found scattered along the line of flight.

RAPID BLUE PRINTING IN CLOUDY WEATHER.

A correspondent of the *Engineering News* says that while experimenting with blue-printing processes with the object of getting bright blues and clear white lines, he found that after the usual washing a bath of quite dilute acid, such as hydrochloric, or, better, oxalic, would often greatly improve the clearness of the prints, a marked cause of dirty blues being a gradual altering of the solutions even when kept separate till just before using, though poor quality of the ammonia citrate of iron seemed to have much to do with the results.

During the experiments he also found that an addition of oxalic acid to the ordinary blue-print mixture materially lessened the time of necessary exposure. The solutions used were:

1. Ammonia-citrate of iron, 120 grains; water, 1 fluid ounce; to which is added a few drops of strong ammonia solution till the odor is quite perceptible.
2. Potassium ferricyanide, 105 grains; water, 1 fluid ounce.
3. Saturated solution of oxalic acid.

Equal quantities of (1) and (2) are taken (*a*); and after being mixed (3) is added as required and the mixture used at once.

Taking, say, in the proportion of 10 ounces of the mixture (*a*) and adding thereto (*b*) 1 ounce; (*c*) 2 ounces; or (*d*) 3 ounces of (3); the relative rapidity of the coated papers will be closely, in very dull light, as 1; 2½ : 5; 10, (*d*) paper being thus about 10 times as rapid printing as (*a*) in the light mentioned. For example, a print was made from a tracing on linen in 35 minutes on February 25, 11.30 A.M., on (*d*) paper during a snow storm, the light being quite dull, while ordinary paper takes the greater part of a day in an equal light.

This great difference only holds good in dark, cloudy weather; as, if comparisons are made in direct sunlight, (*d*) paper is only three to four times as rapid as (*a*). An explanation of this probably is, that a weak light that will reduce to oxalic acid mixture (partly ferric oxalic) has but a faint starting or continuing action on the ferric citrate, while with a strong light both commence at once.

For all ordinary purposes it is better not to use a greater percentage than 20 per cent. (*c*) of the oxalic acid solution, as it is difficult to get the lines to wash white with higher percentage, even with thick black lines on the tracing or negative; and the more sensitive the paper the shorter time it will keep good even in the dark, and also the greater care required in its preparation and use.

HYDRAULIC POWER IN LONDON.

Among the systems of transmitting power to long distances hydraulic power is coming rapidly to the front, and indeed has already held that position for some years in England. We are indebted to a recent issue of the *Engineer* for a description of the plant of the London Hydraulic Power Company, the magnitude of whose operations is rendered tolerably evident by the fact that there is scarcely an important thoroughfare in London in which men may not be seen from time to time laying cast-iron pipes, whose enormous thickness bears ample testimony to the most untechnical passer-by that they are not ordinary gas or water mains.

The London Hydraulic Power Company, with which is associated the General Hydraulic Power Company, has been in existence for about nine years. The general company has the same objects as the London company, but its operations are not confined to any particular city or area. It undertakes the supply of hydraulic power, either in England or abroad, wherever a sufficient demand exists for a system of public supply and the general conditions are favorable.

The general principle involved is, as we have said, pumping water into mains laid in the streets, from which service pipes are carried into the houses to work lifts, or three-cylinder motors when rotary power is required. In one or two cases, however, a small Pelton wheel has been tried working under a pressure of over 700 lbs. on the square inch. The efficiency is over 70 per cent., an extraordinarily high duty. Over 55 miles of hydraulic mains are at present laid in London between Kensington and the London Docks (Shadwell Basin) on the north side, and between Westminster Bridge and the Surrey Docks on the south side of the river, thus embracing nearly the whole of the city, Westminster, Kensington, Wapping, and Southwark. The mains are kept charged by pumping engines located at the Central Pumping Station, Falcon Wharf, Blackfriars; at Millbank Street, Westminster; and at Wapping. A fourth station is in progress in North London, close to the City Road basin. The reservoir of power consists of capacious accumulators, loaded to a pressure of 800 lbs. per square inch, thus producing the same effect as if large supply tanks were placed at 1,700 ft. above the street level. The water is taken from the Thames, or from wells, and all sediment is removed therefrom by filtration before it reaches the main engine pumps.

The power is available day and night, and on Sundays, all the year round, at a pressure of over 700 lbs. per square inch; a pressure which enables small machines to perform a large amount of work with a very small quantity of water.

At Kensington Court a special hydraulic supply to the houses there has been furnished by this company, in conjunction with the manufacturers, the Hydraulic Engineering Company, of Chester. Each house built on the estate is furnished with an improved passenger ram lift on Ellington's system, for domestic use. The lifts are so constructed that they can be worked with safety by even young children. The doors giving access to the lift cannot be opened until the car is at rest at the door to be opened, and the lift cannot be worked until the doors are closed.

The progress of the London Hydraulic Power Company is illustrated by the number of gallons of water power delivered and machines at work during

	Gallons delivered per week.	Number of machines.
July, 1884	317,816	96
" 1885	957,907	235
" 1886	1,379,846	387
" 1887	1,694,621	527
" 1888	2,377,190	720
" 1889	3,339,067	917
" 1890	4,223,751	1,133
" 1891	5,027,616	1,381
" 1892	5,998,249	1,676

At the present time there are over 1,750 machines at work, and the supply is about 6,500,000 gallons per week. Of the existing stations, that at Wapping is the most powerful and complete. Here the water is obtained from a well sunk for the purpose.

The water is obtained from a well sunk for the purpose. The level of the water is about 40 ft. below the surface of the ground. This well is sunk to the level of the London clay. On the top of the clay is a bed of gravel about 8 ft. thick, and the water is pumped out of the bed of gravel. The yield from the well is, when pumping continuously day and night, about 16,000 gallons per hour, and supplies about half the amount required at this station. The quantity required in addition to the yield of the well is taken from the London Dock through a siphon pipe which discharges into the well. The pipes in the well are so arranged that the hydraulic pumps will either draw from the gravel or from the Dock. There is some reason to believe that the water in this gravel bed is neither more nor less than an underground stream flowing parallel to the Thames. A hydraulic pumping engine is fixed in this well, and raises the water to a tank on the top of the boiler house. This pump is driven by water from the pressure mains. The pump cylinder is fitted with a tubular plunger passing through packing at the mouth of the cylinder, and this main plunger itself forms a hydraulic cylinder, fitted with a stationary tubular plunger, through which the high-pressure water passes into and out of the interior of the main plunger. On each side of the main cylinder is a small cylinder; the two plungers of these are connected to a cross-head attached to the main plunger. The small cylinders are always in connection with the high-pressure water-supply, which acts on their plungers with sufficient force to cause the main plunger to make its

back stroke. The stationary plunger is alternately put in communication with the high-pressure supply and with the discharge by means of a slide-valve, which is moved to and fro by the hydraulic pressure acting alternately in a short cylinder at each end of it. The alteration of the pressure in these last-mentioned cylinders is effected by the movement of a secondary slide-valve, which is shifted by tappets on a rod attached to the main plunger. The speed with which the main slide-valve moves is controlled by more or less throttling the passage from the secondary slide-valve to its cylinders. The arrangement permits of a variation of the speed of travel of the main valve, and a pause of any desired length is obtained during reversal of the motion of the plunger. The main plungers are 20 in. diameter, 4 ft. stroke, and work at a speed of 10 strokes per minute.

The water from the well is pumped into tanks over the boiler-house. Here the water settles, and is then collected by floating pipes and passes through filters to the underground filtered water reservoirs. The main engine circulating pumps draw the water from the reservoirs, and force it through the surface condensers into the filtered water section of the tanks over the boiler-house. From these tanks the main engine pumps take their supply under the tank pressure, and force it into the hydraulic power mains. The total reservoir capacity at the station is 800,000 gallons, which is sufficient for one day's supply from the station. The plant for pumping and filling is designed with the intention that it should be at work day and night, while the main engines do not work as a rule more than twelve hours. During the night the hydraulic pumps in the well are worked from the power supplied from the central station, Falcon Wharf, Blackfriars. As a rule, therefore, the main engines start in the morning with all tanks full, and end their day's work with them half empty. These hydraulic pumps are not only economical themselves, but, as it will be seen, give greater facilities for working day and night, as they are quite independent of the supply plant at the particular station where they are fixed. The night watchman stops the pumps and filters when the tanks are full. That is all he has to do.

It is essential that the water used should be clean. The water obtained from the gravel leaves little to be desired in this respect, but that obtained from the docks is by no means pure, and elaborate precautions are taken to purify it. The storage tank extends over the whole boiler-house and coal store. The tank is divided, and a certain amount of mud is deposited here. From thence, as we have said, it passes through the surface condenser of the engines, and it is turned into a set of filters eight in number. The body of the filter is a cast-iron cylinder, containing a layer of granular filtering material resting upon a false bottom; under this is the distributing arrangement, affording passage for the air, as described below; and under this the real bottom of the tank. The dirty water is supplied to them from an overhead tank into which it has been pumped, and is distributed to them by a pipe running the whole length of the building in which they are placed. After passing through the filters the clean effluent is run into a large tank, and is then again pumped into the clean water tank, from which the pumping engines derive their supply. The cleaning of the filters, which is done at intervals of twenty-four hours, is effected so thoroughly *in situ*, that the filtering material never requires to be removed. The operation is as follows: Air is injected by a steam blower, through the distributing arrangement mentioned above, and at the same time a reverse current of water is passed through the filters; this causes the whole of the filtering materials and the impurities contained in it to boil up, as it were. The most violent agitation takes place, and the particles of dirt are thoroughly loosened by the friction of the air and water, without damage to the grain of the filtering material; the dirty water passes through cylindrical screens in the filters themselves, which allow all the impurities to pass away to the drains, while preventing the loss of any of the filtering material. After a few minutes the effluent, which at first starting is like liquid mud, becomes clearer as the air and water do their work, and regains the same tinge as the original sample to be filtered.

The water used for washing is the ordinary unfiltered water. As soon as the cleaning, which occupies but a very short time, has been effected, the filters are ready for work again. The total quantity which these eight filters are guaranteed to deal with is 35,000 gallons per hour. By a suitable arrangement of pipes and valves, a minimum of labor is necessitated, only the opening and shutting of the valves being needed, no manual labor of any kind in the washing of the filters being required. The water is rendered so clean by this process that even if allowed to remain for many days in the tall test glasses which are employed for ascertaining its purity no deposit of any kind is to be found in the bottom, showing that all the mechanical impurities have been eliminated.

The engine house contains six sets of triple-expansion engines, constructed by the Hydraulic Engineering Company on Ellington's system. The cylinders are 15 in. + 22 in. + 36 in. × 24 in. The cranks are set at 120°. Each cylinder drives a single plunger pump with a 5 in. ram, secured directly to the crosshead, the connecting-rod being double to clear the pump. The boiler pressure is 150 lbs. on the square inch. Each pump will deliver 300 gallons of water per minute, under a pressure of 800 lbs. to the square inch, the engines making about 61 revolutions per minute. This is a high velocity, considering the heavy pressure; but the valves work silently and without perceptible shock. All the cylinders are jacketted, and unusual care has been taken to keep them drained back into the boilers by gravitation. The drain-pipes are large and carefully laid, to prevent any accumulation of water in the bends. The steam-pipes are of wrought iron, laid upon the roundabout system. Every portion is practically in duplicate. All the steam-pipes are trapped, and the condensed steam from the traps is collected in a tank and returned by feed-pumps to the boilers. The utmost care has indeed been taken to prevent water finding its way into the cylinders. The engines as a result are found to be very economical, the consumption of steam being 14.1 lbs. per horse per hour. The engines are fitted with surface condensers, as we have already stated. The casing of the condenser forms a part of the engine frame, and each set has its own independent air, circulating, and feed-pumps, driven from the crosshead of the intermediate cylinder through links and rocking shaft, as in marine engines. The circulating water is taken, as already explained, from the filtered water reservoir below the station yard, and is delivered into the filtered water division of the boiler-house tank, from whence it is drawn by the main pumps and pumped into the hydraulic mains. The circulating pumps are of ample capacity to raise the necessary amount of suction water for their respective engines; they thus perform the double duty of circulating and lift pumps. The high-pressure cylinder is provided with Mayer expansion slides, and regulated by hand, by means of a wheel in the usual way; the range of cut-off being indicated on an engraved brass index plate. The cylinders are clothed with non-conducting composition, and covered with planished sheet steel, which is in every way an improvement on wood lagging. The engines are provided with a high speed governor and throttle-valve, and also with auxiliary starting-valve.

The water delivered from the main pumps passes into the accumulators, which are among the largest constructed. The rams are 20 in. in diameter, and have a stroke of 23 ft. They are each loaded with 110 tons of slag, contained in a wrought-iron cylindrical box, suspended from a crosshead on the top of the ram. The area of each ram is 314 sq. in., and the pressure being 800 lbs. on the square inch, the total load is 314 × 800 = 251,200 lbs., or a little over 112 tons. Allowing 5 per cent. to overcome the friction of the packing, etc., we have 120 tons, the extra 10 tons being supplied by the weight of the ram and the casing. One of the accumulators is loaded a little more heavily than the other, so that they rise and fall successively; the more heavily loaded actuates a stop-valve on the main steam-pipe. If the engines supply more water than is wanted, the lighter of the two rams first rises as far as it can go, the other then ascends, and when it has nearly reached the top, shuts off steam and checks the supply of water automatically. Although one accumulator is always in advance of the other, the difference of load is so small that both move at the same time. The result is that the pressure is maintained in the mains with very great regularity.

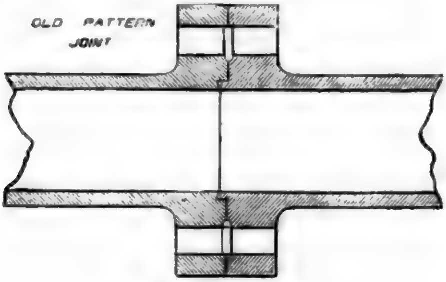
Steam is supplied by six boilers fitted with economizers and mechanical stokers. The boilers throughout are of Siemens-Martin steel, and each one consists of a top and bottom vessel connected by steel "blocks." The top vessel is 21 ft. long and 4 ft. 6 in. diameter, with flanged and dished ends. The bottom vessel is 18 ft. long, 5 ft. diameter, and is fitted with a flue, 3 ft. 9 in. diameter. The flue is composed of welded and flanged rings, connected by a tube-plate to a battery of 3 in. tubes at the back end. This flue is fastened to the front and back end plates by bolts, the joints being specially prepared. This enables the flues to be drawn out for inspection and cleaning. To facilitate the operation a rail is fixed to the shell on which the pulleys attached to the flues run. A longitudinal dome or receiver is placed on the top of the boiler to insure perfectly dry steam. The boiler being so quick a steam raiser, this dome is advisable also, on occasion, to prevent priming.

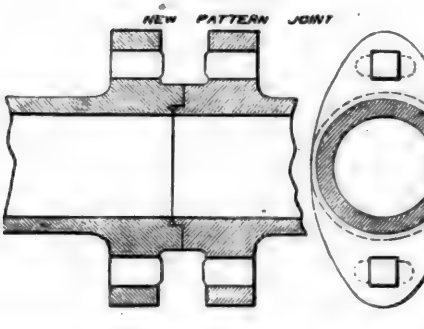
The coal when delivered at the station is discharged by a 20 cwt. hydraulic crane, which raises the coal in buckets from the lighter in the adjacent dock on to an elevated staging, from whence it is run in a truck to the coal store adjoining the fire-

room. From the coal store it is taken as required in a hopper-bottom truck, which is raised by a hydraulic lift on to an elevated roadway over the fire-room and discharged into a conveyor hopper, from whence it is carried to the several stokers as required.

The boilers and economizers together have evaporated 11.1 lbs. of water at 146 lbs. pressure from the hot well temperature with 1 lb. of Nixon's navigation coal. Combining the best results obtained on trial of the engines and boilers, the coal used per indicated horse-power works out at 1.27 lbs.

It will be readily understood that it is of the first importance that the mains in the public streets should be so constructed and laid as to be perfectly trustworthy and free from leakage. The velocity of water flowing from a free orifice with a pressure of 700 lbs. per square inch being about 320 ft. per second, a very small hole in a pipe may lead to a large escape of power. Every pipe and valve used throughout the system is tested to 2,500 lbs. per square inch before being placed on the ground, and again tested to a reduced pressure in the trenches to insure the perfect tightness of the joints. The jointing material used is gutta-percha, on the system introduced by Lord Armstrong many years ago, but the form of the flanges has been modified by Mr. Ellington so as to insure their being of even greater strength than the body of the pipe.





Pipes subject to high pressures, such as are employed for conveying water to work hydraulic machinery, are usually jointed as shown in the first of the diagrams on page 45. When such pipes are subject to excess of pressure, or when they are overstrained in the act of jointing, they generally give way right through one of the corners. By facing the flanges of the two pipes with projecting bosses of some height as indicated by the second section, and thus increasing the depth of the line along which fracture would otherwise take place, the pipes are made as strong at the jointing as in any other part.

Practically, no failures of pipes have occurred since this improvement was effected. At the present time there is no appreciable leakage on the system.

The hydraulic power is sold by meter, the charges being based on a sliding scale, commencing with a minimum charge of 25s. per quarter per machine, for which sum 3,000 gallons is supplied, and where the consumption is up to 500,000 gallons per quarter the charge is 2s. per thousand gallons. For very large consumptions the charge is still further reduced. We believe the average rate obtained by the company is about 3s. per thousand gallons. The principal use of the power is for intermittent work in cases where direct pressure can be employed, as, for instance, passenger elevators, cranes, presses, warehouse hoists, etc. For such purposes hydraulic power has been long recognized as being the best and most trustworthy. It is not surprising, therefore, to find that this company has secured so large a share of the lifting work of London. It has been proved more convenient and satisfactory than any private system of power supply, and the sliding scale of charges adopted by the company has enabled it to meet the requirements of both small and large consumers with profit to itself and the public. Circumstances differ so widely that it is not perhaps possible to make any general statement as to the economy of power over older systems, but in many cases proprietors of wharves have found the saving sufficient to pay the cost of the new hydraulic machinery substituted for steam or other plant in three or four years. In a great number of cases also the pumping machinery of existing hydraulic plant has been abandoned, the company's charges being found to be below the actual running expenses of the consumer's own plant. In new premises there is of course the large additional saving in the smaller outlay of capital required. The most notable instance of the economy of the public supply system is perhaps at the London Docks, where about half the power used is now taken from the company; but most of the principal railways, wharves, hotels, warehouses, and office buildings now make more or less use of the company's power. There are also a good many rotary motors at work, principally Brotherhood's well-known three-cylinder hydraulic engine. The electric current used by the Exchange Telegraph Company is obtained from a dynamo worked from the hydraulic power mains, and in addition to the hydraulic engine fitted up for it by the Hydraulic Engineering Company a few years ago, the company has recently fixed for it a Pelton wheel. Such a wheel is obviously well adapted for dynamo driving, and it is interesting to note that the difficulties of employing pressures of 700 lbs. or 800 lbs. per square inch have been overcome.

A very important use of the hydraulic power requires to be noticed—*i.e.*, its application to the extinguishing of fire by means of Greathead's injector hydrant; about 100 of these hydrants are in use. Queen Anne's mansions, St. James's Park, have them on every floor. The buildings of New Scotland Yard and the National Gallery are also fitted with them, and there are a few in the streets. By the use of these hydrants a continuous fire-engine is available.

The system of hydraulic power which we have been describing is being adopted in other towns. It was first established in Hull in 1875; then came London in 1882; Liverpool followed in 1886. The system has also been established in Melbourne and Sydney. The Birmingham Corporation recently commenced to supply hydraulic power on their own account, and works have just been commenced in Manchester and Glasgow. The development of this branch of hydraulics has been almost exclusively of English origin and growth, and at the present time it may confidently be stated that nothing approaching to the installation we have been describing is to be found elsewhere. The capital outlay in London has been nearly £400,000, and the dividend paid for 1891 was 5½ per cent.

ELECTRIC CAR LIGHTING ON THE NORTHERN RAILWAY OF FRANCE.

THE *Journal des Transports* is authority for the statement that the Northern Railway of France is about to make an application of electric lighting to the saloon cars, sleeping cars and first, second and third-class compartment cars in use upon their system. The step is to be taken after prolonged tests upon isolated cars, and it has been decided to experiment upon a larger scale with regular arrangements, devised as a result of these experiments which have been carried on between Paris and Lille.

Each car is lighted by a storage battery furnishing the current to lamps of 6, 8 and 10 candle-power, according to the class of carriage in which they are used. The arrangements are also so made that oil may be substituted for the electric lighting at a moment's notice, and that, too, without disturbing any of the electrical apparatus.

The storage batteries are sixteen in number, and are enclosed in groups of two in a small and easily handled box. These eight double batteries are suspended from the sills, and are accessible at the sides from the footboards, and are closed by doors turning down upon the footboards themselves.

Each battery is composed of nine plates, of which four are positive and five negative, contained in a small ebonite case arranged to receive 11, of which five are positive and six negative. These plates are 7¼ in. high, 4 in. wide and ⅛ in. thick; each weighs 2 lbs., or, to speak more accurately, the weight

per cell is 17.6 lbs., and they have a capacity of 6¾ ampere-hours per pound of lead. The weight of each cell, inclusive of accessories and liquid, is 28 lbs.; the two cells enclosed in the box weigh 66¼ lbs. and the whole 16 cells 529 lbs., to which must be added 330¾ lbs. for the casings beneath the cars. The whole battery has a minimum total capacity of 113.4 ampere-hours. The lamps are of the 30-volt type of 10 candle-power for first-class compartments, saloon cars and sleepers; of 8 candle-power for second-class compartments, and 6 candle power for third-class cars, lavatories and closets. They consume 2.9 watts to 3 watts per candle-power, and have a minimum duration of 30 hours. They are carried by a stem of cylindrical hard wood, which supports, at the same time, the lamp socket and the reflector, which is a sheet of white enamel. The apparatus is enclosed in the lantern itself in the place of the oil lamp. The wires are let into a block of hard wood set into the ceiling near the lantern opening.

The switches are enclosed in a small box at the two opposite ends of the car, and are so arranged that the lamps may be lighted or extinguished from either one without leaving the footboards and the batteries recharged without moving them from their positions. Finally the principal wires connecting the batteries with the lamps and switches have a special insulation so as to register mechanically and electrically any damage or injury from the weather. These wires run along the sills, to which they are fastened by clamps of zinc solder. When an oil is to be substituted for an electric lamp, the lantern is opened and the electric lamp with its support removed and the oil lamp put in its place. There is no need of taking any special precautions in this work.

The first cost of the apparatus has not been definitely settled as yet because only a small number of cars have been equipped. It is somewhat expensive, but the following figures may be considered to be above rather than below the probable average: First-class compartments, \$145; second-class, \$148; third-class, \$150; and \$140 for baggage vans. As we have said, this first cost has not yet been accurately determined, and the extensive experiments which have been undertaken by the company have just this very object in view. Meanwhile what has already been done permit of the expectation that the actual cost will not vary very much from the figures given even when a better light is provided

In conclusion, the duration of the light will be quite long, as the batteries can furnish about 33 hours' continuous lighting without being touched. The lamps need attention about once in 18 hours.

A PECULIAR EXHAUST NOZZLE.

A RECENTLY designed engine on the Northern Railway of France is provided with a novel exhaust nozzle, for the engravings of which we are indebted to the *Revue Générale des Chemins de Fer*. There is a bronze flap valve located beneath the regular nozzle, that may be adjusted by the engine driver in either of the two extreme positions; one permitting a free exhaust in the ordinary manner, and the other turning the steam into the pipe *t* which is placed against the inside of the stack and opens into the atmosphere. This pipe is oblong in form, as shown by the sectional cut at the bottom of the engraving. The flap may also be fixed in the intermediate position as shown.

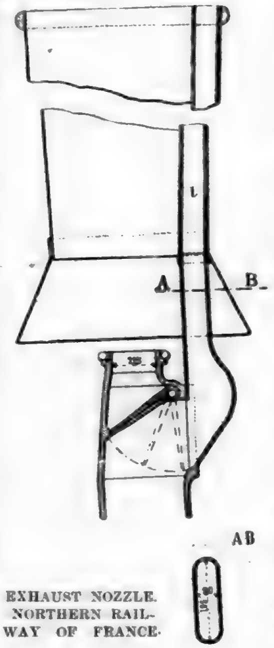
This arrangement has been adopted after a prolonged trial upon old tramway engines, whereon the tests were most satisfactory. The startings which occur with a full admission of steam into the cylinders are ordinarily too frequent for these locomotives, and the result is that with the regular exhaust the draft is excessive. The inconveniences resulting from this have entirely disappeared with this new arrangement.

EFFECT OF TURPENTINE GATHERING ON THE TIMBER OF LONGLEAF PINE.

THE following circular, No. 9, has been issued by Mr. B. E. Fernow, Chief of the Forestry Division of the Department of Agriculture, and should go far toward settling the question under dispute. Personal conversation with longleaf pine lumbermen of the South has convinced us that the statements of the circular are true, for it is the unanimous testimony of all with whom we have talked that turpentine gathering has no appreciable effect upon the timber. Still the specifications of many of our leading roads require that all yellow pine shall have been untapped. Whether they get it or no is another question.

"In Circular 8 of the Forestry Division, published about a year ago, it was stated that tests made on timbers of longleaf pine, bled or unbled, lent countenance to the belief that bled or tapped timber did not suffer in strength by virtue of the tapping. Further tests and examinations permit now the announcement without reserve that *the timber of longleaf pine is in no way affected by the tapping for turpentine.* This refers to its mechanical as well as chemical properties, and hence even the reservation that it might suffer in durability is now eliminated, and any prejudice against the use of bled timber in construction, wherever the unbled timber has been considered desirable, must fall as having no foundation in fact, being based only on vague belief, proved to be erroneous.

"It is to be hoped that this fact will be made widely known among builders, architects, and engineers who have hitherto made discrimination against bled timber, and thereby depreciated or discouraged the manufacture and impeded the sale of an article which answers all the purposes of construction and the unrestricted use of which is dictated by true economy.



EXHAUST NOZZLE. NORTHERN RAILWAY OF FRANCE.

"The basis for the statement regarding the mechanical properties is furnished by a series of tests comprising not less than 300 tests on 32 trees of this pine, bled and unbled, from various localities.

"The somewhat puzzling fact that bled timber exhibited, if anything, greater strength in the tests has been accounted for by the fact that the turpentine orchards are located mostly on sites which produce better quality timber as well as larger yield of turpentine.

"To determine whether any changes in the chemical composition take place, a series of chemical analyses of bled and unbled timber has been made, which indicates that the resinous contents of the heartwood are in no wise affected by the bleeding, the oleoresins of the heartwood being nonfluid, the whole turpentine flow is confined to the sapwood.

"Among other interesting facts regarding the distribution of resinous contents through the tree which will be published in a separate bulletin, it appears that trees standing side by side and to all appearances in similar conditions show very varying quantities of resinous contents.

"To make sure that experience did not, if sifted down, contradict the results of these investigations, a competent agent, Mr. F. Roth, visited turpentine orchards and sawmills in the longleaf pine region. He reports that nobody was found—although it was claimed by some—able to discern any difference in the appearance of the bled and unbled timber; that in spite of consumers' specifications for unbled timber, they are almost invariably served with a mixture without finding it out; that experience in the districts where bled timber is cut and used has not sustained the claim of inferiority.

"This information is furnished in advance of the full report on the investigations in question, in order to remove as quickly as possible the unwarranted discrimination against the product of nearly one million acres of Southern pine, which are annually added to the total acreage in turpentine orchards.

"This result of authoritative investigation should be worth several million dollars to the forestry interests of the South, permitting readier use and sale for a product that left uncut endangers the future of the forest by the destructive conflagrations to which it is specially subject."

NEW LAKE PASSENGER STEAMERS.

The Northern Steamship Company, of which J. J. Hill is President, and which is controlled by the Great Northern Railroad Company, has placed an order with the Globe Iron Works Company, Cleveland, O., for the construction of two of the speediest and largest steamers ever built on fresh water, the contract to be completed for the opening of navigation in 1894. For the accompanying engraving and the description given, we are indebted to the courtesy of the Cleveland *Marine Record*.

These vessels are to run between Buffalo and Duluth, a distance of 1,000 miles, at the rate of 20 miles an hour, thus completing an important link of the Great Northern system of transportation between New York and Boston on the east, and Puget Sound, in the State of Washington, to the west.

NEW PASSENGER STEAMER FOR THE NORTHERN STEAMSHIP COMPANY.

The engraving shows the general appearance of these steamers. Their principal hull dimensions are to be 380 ft. over all, a length never before attained on the lakes; 360 ft. keel, 44 ft. beam, and 34 ft. molded depth. The engines are to be of the vertical quadruple expansion type, and arranged in the following order: High-pressure cylinder, 25 in. diameter; first and second intermediate cylinders of 36 in. and 51½ in. respectively, and low-pressure cylinders of 74 in.; stroke of piston, 42 in.; to develop 7,000 H.P. The engines will have Joy valve-gear. The boiler power will consist of a battery of 28 Belleville boilers, to carry 225 lbs. steam pressure; independent air pumps and condenser, electric-lighting plant, patent windlass, steam steering-gear, and steam capstans and every modern appliance in the list of high-classed equipments will be furnished these steamers, which are considered as being a masterpiece in the art of lake shipbuilding.

The advantages of twin screws for vessels required to develop a high rate of speed are so manifest that they promise to soon supersede the single screw entirely; but at the present time only the finer class of boats are being fitted with the twin screws, chiefly, we presume, on account of the initial cost and space required for extra machinery. The entire lower holds of these two new steamers, however, are to be given up to the engines, boilers and fueling space, and their propeller wheels will be 13 ft. in diameter by 18 ft. pitch, supported by heavy steel brackets arranged on each side abaft the boss plates.

The cost of these two steamers is $1,100,000, or $550,000 each, and it is officially stated that they are the precursors of a fleet of six similar vessels which will make daily sailings from each end of the lake route as soon as the western terminus of the Great Northern Railroad system is established and the freight and passenger trade to Australia, China and Japan becomes developed. The Great Northern has already a fleet of six large steel freight steamers which have been engaged in the advancing lake trade between West Superior and Buffalo for the past four years, and with the advent of what will certainly be the finest passenger boats ever placed on the lakes, the passenger traffic will no doubt be largely increased.

As shown by the engraving, the new boats will resemble ocean steamers in their general appearance much more than the usual type of lake steamers.

ACCIDENTS TO WORK-PEOPLE.

The United States consul at St. Étienne has reported an abstract of the work of the International Congress, which recently met at Berne. The analyses, general treatment, and marshalling of statistics bearing on the subject of accidents to working people were scientific, skilful, and thorough. It was shown that there are 100 accidents to each 10,000 workingmen, one-half fatal and one-fourth producing permanent injuries. While Belgium, England, France, and Italy give to a certain degree, information as to accidents in mines and on railways, Switzerland published a detailed statement of all accidents reported between April 1, 1888, and March 31, 1889. In Germany, according to the Imperial Assurance office, there were in 1889, 15,970 injured by accidents, of whom 2,956, or 18.51 per cent., were killed, and 13,014, or 81.49 per cent., received injuries rendering them incapable of returning to work under three months. The classification of the fatal injuries was: Crushed under masses or objects, 801; falling, 512; machinery, 469; molten, liquid or irrespirable gases, 295; cars, carriages, etc., 236; railways, 149; weights, 130;

drowning, 117; explosives, 86; animals, 42; steam boilers, 36; tools, 30; other causes, 53; total, 2,956. There are moral and material causes for accidents, the former arising from the fault of the employers or workmen and from unforeseen causes. The latter are more difficult to determine. In France there is, at the office of the Minister of Public Works, a committee to inquire into the causes of steam-boiler explosions. In 1889 the presumed causes of such explosions were given as: Wear and tear, 17; defective condition of construction and installation, 15; want of water, 8; over-pressure, 5; defective repairs, 3; other causes, 3; total, 51.

The following statement shows the proportions of responsibility on employers and employed for the 15,970 accidents to work-people in Germany:

	Per cent.	
Accidents imputed to employers:		
Insufficiency of preventive measures	10.01	
Defective construction	7.05	
Insufficiency of rules	2.69	
		19.75
Accidents imputed to employed:		
Awkwardness, inattention, etc.	10.73	
Infraction of rules	5.17	
Manifest imprudence	1.98	
Neglect of using preventive measures provided	1.76	
		19.64
Accidents where both parties were to a certain extent at fault:		
Dangers inherent in the industry	49.41	
Simultaneous negligence	7.73	
Unknown causes	3.47	
		60.61
		100.00

In most accidents the savings of the workman are inadequate to provide resources for his family, and consequently it has been the custom to resort to a special system having the object of (1) collecting individual savings under the form of subscriptions. (2) Creating a common purse with these subscriptions to cover the risks to which the workman is more or less exposed. (3) Compensating the victim of an accident according to fixed rules. The Congress studied thoroughly the question of accidents, and resolved that it was more necessary to prevent accidents than to compensate for them, as the economical transformations, the establishment of thousands of workshops, and the concentration of workmen in exceedingly narrow limits, have increased the chances of accidents, and even caused appalling catastrophes. The French and other civil codes are no longer in harmony with the needs of the workman. Accidents are daily happening, but the Civil Code provides only for those arising from the negligence of the employer, whose responsibility is often not easily established, it having been shown before the Conseil des États de la Suisse that proof of the employers being in fault failed 75 times out of 100. The new and seductive formula of the obligatory insurance of workmen has obtained many partisans, it being no longer believed that individual initiative or private associations can guarantee sufficient provision against accidents. This being agreed upon, the Congress discussed the question whether the insurance should be entirely arranged by the State or left to the free choice of private individuals or societies. The German delegates endeavored to show that the State alone could properly take in hand the defense of the working classes—the real social organization. The representatives of Anglo-Saxon and Latin countries, especially the French, maintained that it was preferable to leave to each State the liberty to organize the insurance system according to its habits. After prolonged discussion the Congress accepted unanimously the principles of obligatory insurance, leaving to each country the choice of applying it according to its customs and existing institutions.

KRUPP'S NICKEL-STEEL CANNON.

A BOARD of Austrian Army officers recently visited Krupp's works at Essen to make a special report on field artillery. During this visit, which lasted five days, the board inspected the crucible steel foundry and also the foundry where Krupp makes his nickel steel by a process which is kept secret.

The board examined fragments of a nickel-steel cannon which had been burst with a detonating shell. The fibrous character of the fractures, together with the tests to which the specimens were subjected, demonstrated that nickel steel possessed all the necessary qualities of solidity and elasticity.

Further experiments were made at the polygon at Meppen with two Krupp field guns, 3.53 in., one of which was of crucible steel, the other gun of Krupp's nickel steel. In each of these guns they placed a shell containing a charge of 6 oz. of picric acid.

The middle point of the projectile was accurately adjusted in the bore of each gun to be at a distance of 11.8 in. from the muzzle of the gun.

Upon the explosion of the shell the crucible steel gun was burst at the seat of the shell, and a number of pieces were collected weighing variously from 4 oz. to nearly 4 lbs. The nickel-steel gun remained intact, and, with the exception of an enlargement of the bore by .29 in. at the seat of the projectile, was uninjured.

They then put a shell loaded with 6.35 oz. of picric acid in the same nickel steel gun in the same position in the bore as in the former experiment. The shell was exploded in the gun and caused an enlargement of the bore at the seat of the projectile by .374 in., and also caused a longitudinal crack 3.15 in. long in the bore. Not a particle of metal was broken off from the gun.

The new metal was subsequently tested as armor plate. The plate of nickel steel, 13.66 in. thick, had previously sustained the blows of five projectiles. In this trial they fired a projectile of 6.7 in., weighing 158.4 lbs., at a distance of 132.3 yds. The projectile penetrated the plate and was recovered 1,301 yds. beyond. It made a clean hole in the plate of the size of the projectile, but did not fracture the plate. The diameter of the projectile was increased by .027 in., and its length reduced by .134 in.—*Army and Navy Journal.*

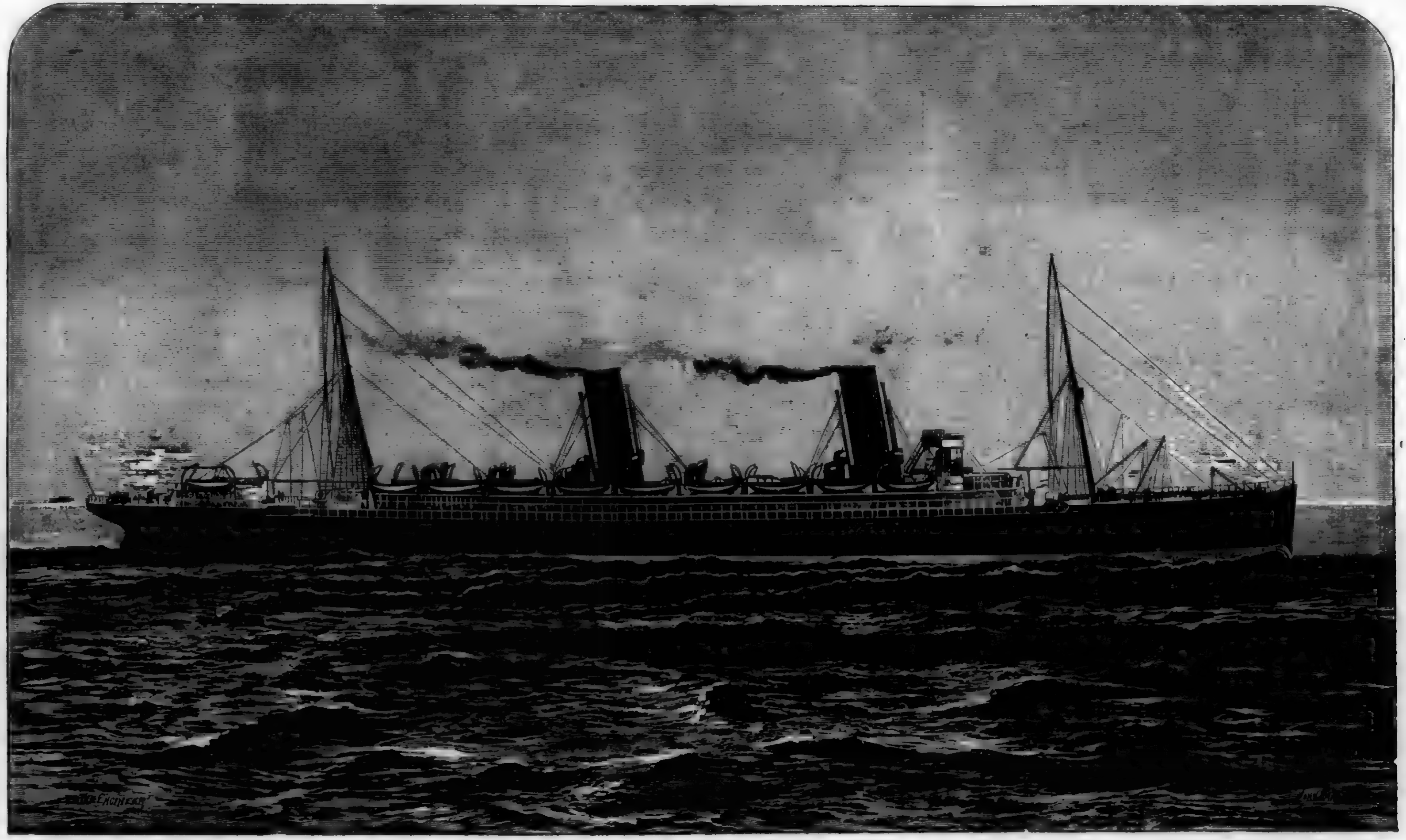
THE CUNARD COMPANY'S NEW TWIN-SCREW STEAMSHIP "CAMPANIA."

THE *Campania*, the first of the two magnificent vessels now being built by the Fairfield Company for the Cunard Line, is approaching completion in the wet dock of the builders. The engines, boilers, funnels uptakes, steam pipes, shafting, and other items which make up the total of the *Campania's* propulsive machinery were almost entirely ready for fitting on board at the date of her launch, and since that time no delay has taken place in getting this ponderous mechanism on board. A first trial, or turn, of the engines and propellers took place in the company's dock, the engines and shafting being then driven at about 25 revolutions per minute—about one-fourth of the speed at which they are intended ultimately to work.

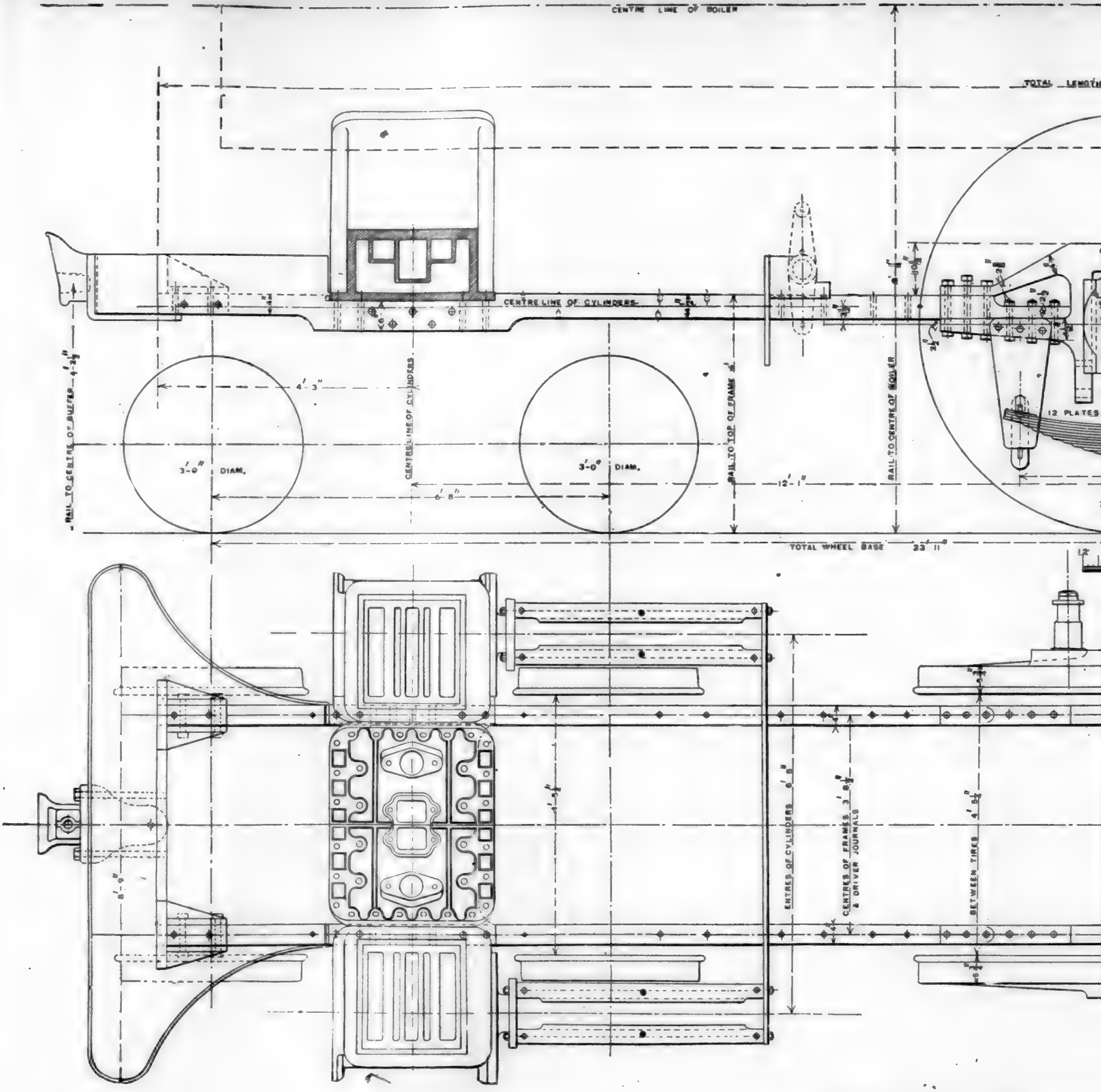
It may be safely said that the present is the twin-screw era of Atlantic navigation. It was inaugurated in 1888–89, when the four notable steamships, *City of New York*, *City of Paris*, *Majestic*, and *Teutonic*, were brought into the field, and it was soon further signalized by the introduction into the same service of the fine twin-screw vessels, built and owned by German and French firms—*e.g.*, the *Augusta Victoria* and *Fürst Bismarck*, of the Hamburg-American Line, and *La Touraine*, of the Compagnie Transatlantique. At the present time there are built and building as many as 35 twin-screw steamships of over 5,000 tons, the *Campania* making the fifteenth vessel to be produced of over 6,000 tons.

The *Campania* is for the present the longest and most capacious steamship afloat, her 600 ft. length between perpendiculars being only 80 ft. short of that of the late lamented *Great Eastern*, and her beam of 65.7 ft. being 17 ft. less than the defunct leviathan. The vessel in actual service most nearly approaching her in length is the White Star *Teutonic*, which is 566 ft. between perpendiculars, or 34 ft. less, the beam being 8 ft. narrower. The *Campania* is 78 ft. longer, but only 1 ft. 9 in. broader than the Inman Company's *City of Paris* and *City of New York*. Her length over all is 620 ft.; breadth extreme, 65 ft. 3 in.; depth to upper deck, 43 ft., and gross tonnage, about 12,500 tons. Her displacement will probably be 18,000 tons. The vessel has a straight stem and elliptic stern, top gallant forecastle and poop, with close bulwarks, all fore and aft, and erections above the upper deck consisting of two tiers of deck houses, surmounted respectively by the promenade and shade decks.

The *Campania* is fitted with two sets of the most powerful triple-expansion engines that have yet been constructed, each set capable, it is believed, of indicating from 14,000 to 15,000 H.P. These engines are fitted in two separate engine-rooms, there being a dividing center-line bulkhead between them, fitted with water-tight doors for the necessary purposes of communication. Each set of engines has five inverted cylinders—viz., two high-pressure, one intermediate-pressure, and two low-pressure cylinders; the two high-pressure being placed tandem-wise above the low-pressure ones. These are arranged to work on three cranks, set at an angle of 120° with each other. The high-pressure cylinders are each fitted



THE NEW CUNARD TWIN SCREW STEAMSHIP "CAMPANIA."

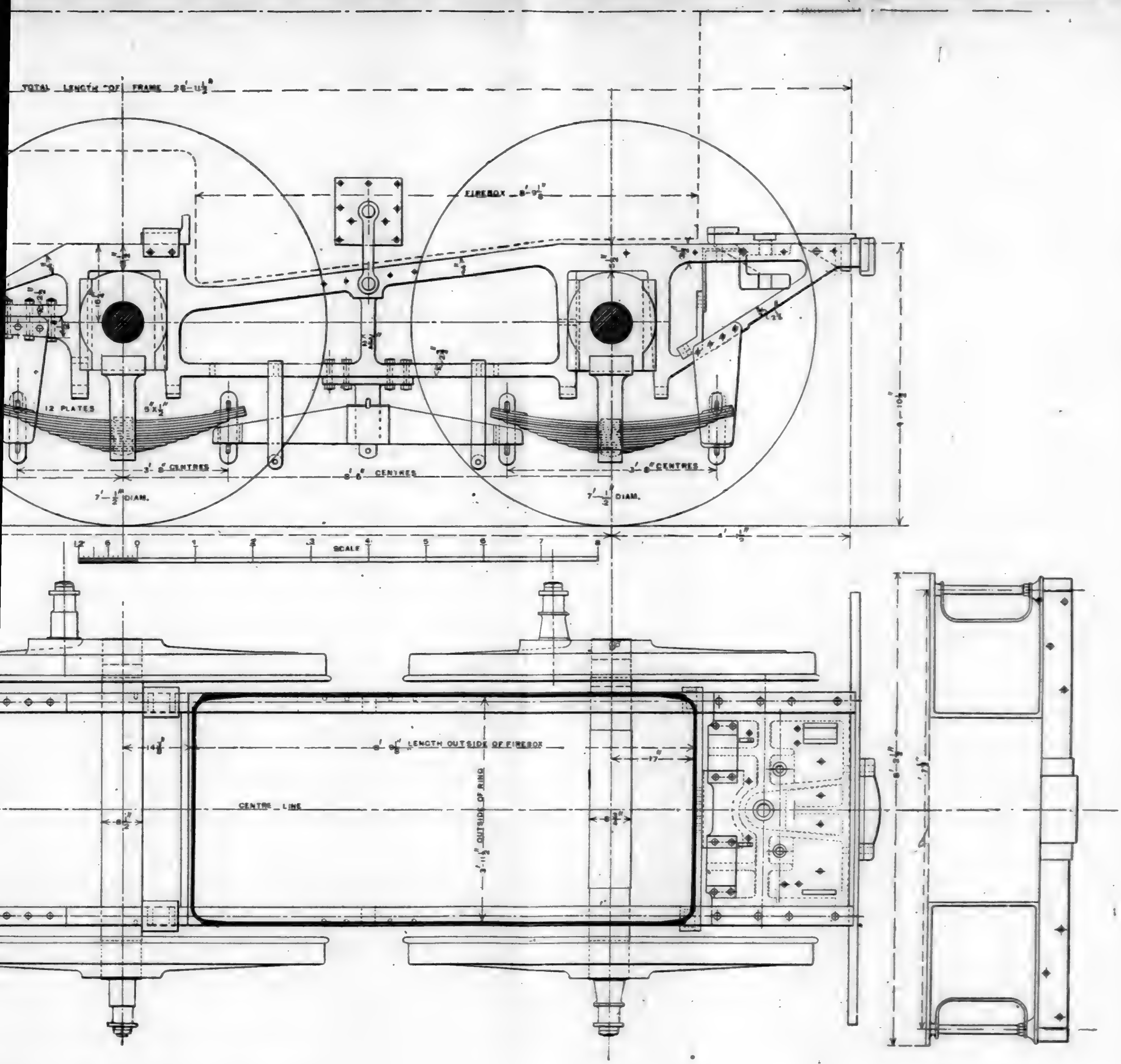


FRAMES OF AMERICAN EXPRESS

DESIGNED BY MR. WILLIAM BUCHANAN, SUPERINTENDENT OF MOTIVE P

BUILT BY THE SCHENECTADY LOCOMOTIVE

(*For description, see p*

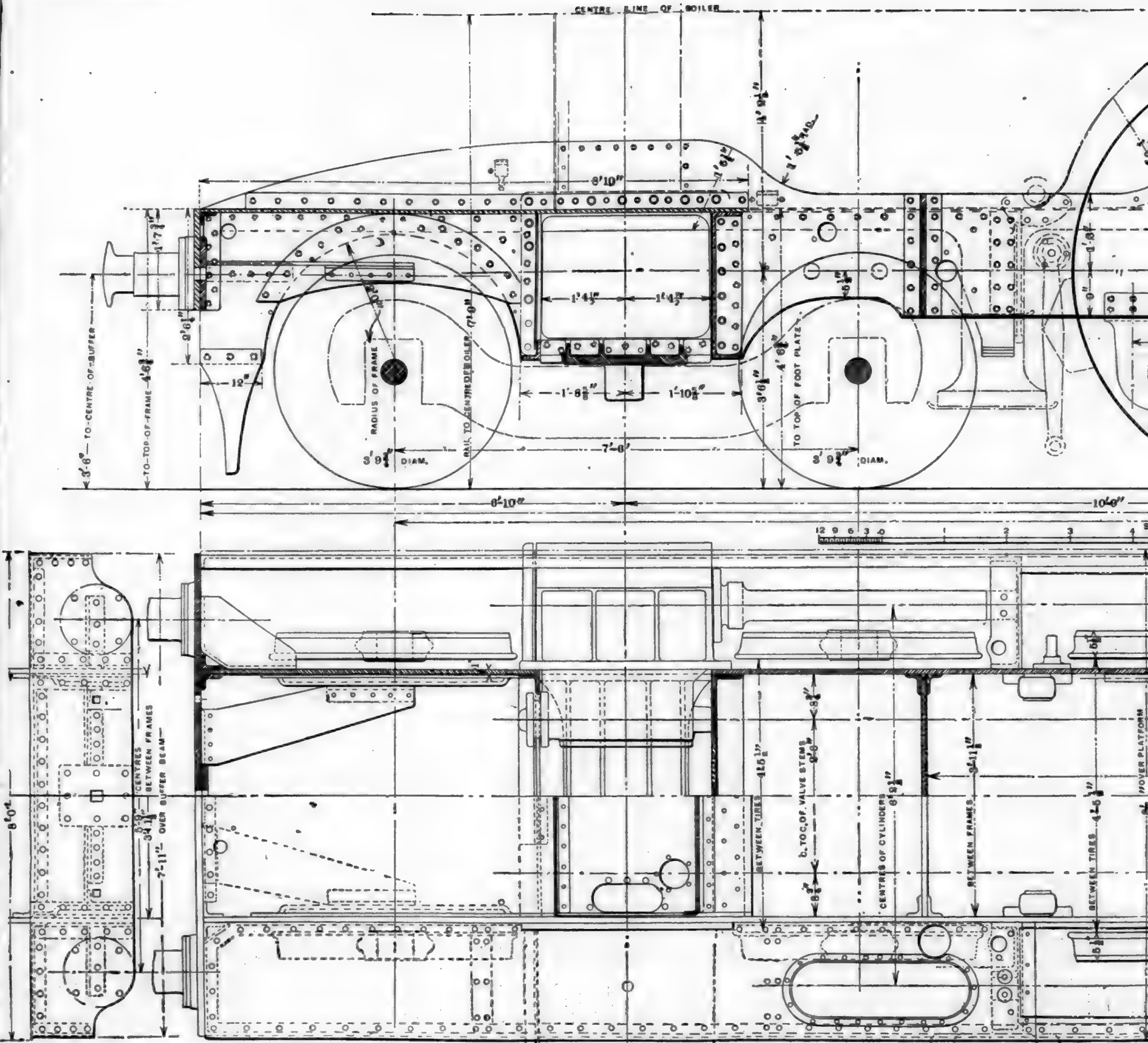


AN EXPRESS PASSENGER LOCOMOTIVE.

T OF MOTIVE POWER OF THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

DY LOCOMOTIVE WORKS, SCHENECTADY, NEW YORK.

or description, see page 116.)

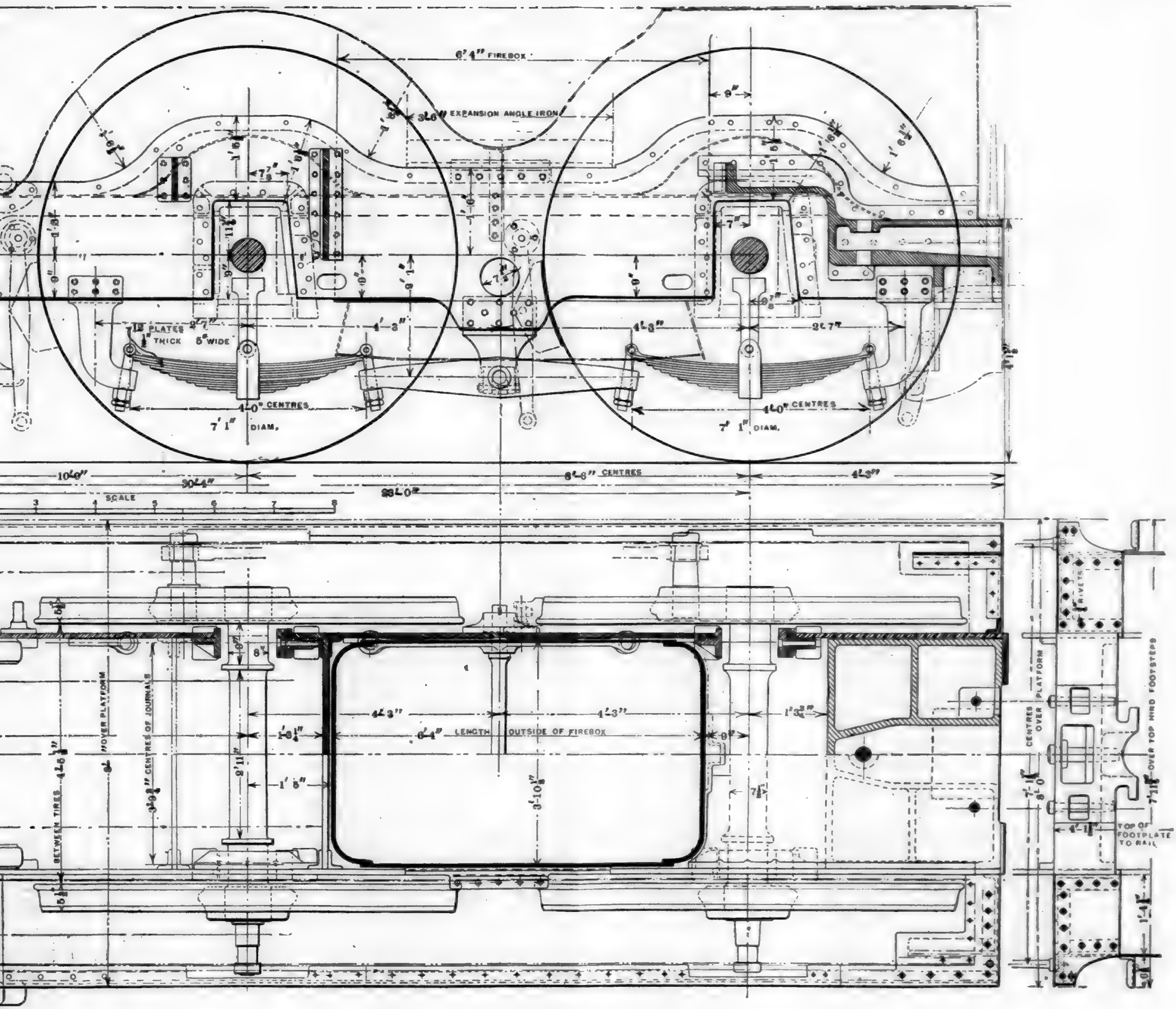


FRAMES OF ENGLISH EXPRESS

DESIGNED BY MR. W. ADAMS, LOCOMOTIVE SUPERINTENDE

BUILT AT THE NINE ELMS WO

(*For description, se*



SH EXPRESS PASSENGER LOCOMOTIVE.

VE SUPERINTENDENT OF THE LONDON & SOUTHWESTERN RAILWAY.

E NINE ELMS WORKS OF THAT COMPANY.

(*For description, see page* 116.)

With the decay of the commercial supremacy of Greece this line was abandoned, and it is not until 1438 A.D. that another application of the principle was made, and then it was for warlike purposes. In that year the Venetians, following the plans of Nicolo Sarbolo and Blaiso de Arboribus, carried 30 galleys overland from the River Adegie to Lake Garda, 1,000 oxen, assisted by windlasses on the steeper grades, furnishing the motive power. One vessel alone was lost. The renown of this exploit was so great that it came to the ears of Soleiman Pacha, who, in 1453, employed a similar expedient at the siege of Constantinople, transferring his fleet over timber ways, greased and laid on trestling and staging. By this move, which was accomplished in a single night, Soleiman avoided the chain which formed an impassable barrier across the Hellespont, and succeeded in mooring his vessels in the Golden Horn under the walls of the besieged city, which soon capitulated.

Coming to more recent times, it may be mentioned that in 1718 several vessels were conveyed from Stromstadt to Idelfal, n Sweden, by Count Emmanuel Swedenborg, then a humble engineer, who was ennobled for the achievement. In 1826 the Cornish system of ship transportation was completed. The canal boats in the Bude Canal, at Hobbacote Downs, ascend an inclined plane 900 ft. long, provided with two lines of rails terminating at each end in the canals. Here the boats, which were provided with small iron wheels, were raised by an endless chain moved by two tanks alternately filled with water and descending into deep wells. Altogether there were seven such inclines in this canal. I come next to some American enterprises of a similar character. One was the Portage Railway from Hollidaysburg to Johnstown, Pa., which was completed in 1834, to connect the canal systems of eastern and western Pennsylvania. On this road a system of gravity railways, with ten inclined planes, the large boats of the Pioneer Packet Line were carried up and down until the completion of the Pennsylvania Railway. Another portage constructed on the same principle was completed about the same time on the Morris & Essex Canal in New Jersey, and one proposed by Josiah White for the Lehigh Canal in Pennsylvania.

The scheme of Sir James Brunlees, proposed in 1860 to the Emperor of the French, to build a ship railway across the Isthmus of Suez instead of the canal, produced a good deal of excited feeling in engineering circles. It was referred by the emperor to Marshal Vaillant, then Minister of War, who, in turn, passed it over to M. de Lesseps, who naturally rejected it in favor of his own canal scheme. The proposed railway would, it was claimed, have had the advantage of greater speed, for it would have carried the vessels at the rate of 20 miles an hour, and the estimated cost was only one-seventh that of the ship canal. The railway was to have been level throughout, and the ships were to have been supported on a framing of iron resting on wheels and springs, and these again on 10 rails. In Germany, vessels of 60 tons capacity have been carried for the past 20 years from the upper portion to the lower of the Elbing Sherland Canal. Among other undertakings of the same kind proposed, or in progress, was a project submitted to the Honduras Government, to construct a ship railway across its territory from Puerto Cabellos to the Bay of Fonseca. Then some years afterward came the preparation of plans for a ship railway to overcome the cataracts of the Nile. Next in order was Captain Ead's famous scheme for the Isthmus of Tehuantepec. The ship railway in this case was to be 130 miles long between the Gulf of Mexico and the Pacific Ocean, with gradients of 50 ft. to the mile. In the Hioto Canal in Japan the expedient of transporting boats over a railway in order to avoid locks was adopted. There the installation as a whole with the employment of Pelton water-wheels, dynamos and motors, driven by the water falling from the higher level was exceedingly novel.

We now come to the Chignecto Ship Railway, commenced in 1888 and at present about three-fourths finished. That narrow neck of land between the Gulf of St. Lawrence and the Bay of Fundy known as the Isthmus of Chignecto, which connects the province of Nova Scotia with the mainland of Canada, has been a fruitful field for engineering theories. For more than 100 years schemes have been advanced for uniting these waters by means of a canal, which would enable vessels to pass through from the St. Lawrence to St. John, New Brunswick, Portland and Boston instead of proceeding by the present dangerous and circuitous route around the peninsula of Nova Scotia. Engineers employed by the governments of Canada, New Brunswick and Prince Edward's Island have time after time surveyed the proposed route, but they have all come to the conclusion that a canal, accessible at all times of the tide, would not only cost an enormous amount to build, but would involve the expenditure of large sums in repairs and maintenance. The Bay of Fundy, remarkable for the range of its tides, was found to contain vast quantities of alluvial matter, which would quickly be deposited in the locks and waterway, which would thus be filled up. There was, moreover, a difference in the tidal level between the gulf and the bay of from 17 to 23 ft., and the necessity of providing locks to overcome this difference of level would have involved a great delay in the passage of vessels. Thus it happened that the canal scheme was finally abandoned, while a proposal by Mr. Ketchum for a ship railway for the conveyance of vessels with their cargoes bodily across the isthmus, was adopted as a substitute.

Eleven years ago, just 99 years after the idea of a canal had first been mooted, the Chignecto Marine Transport Railway Company was incorporated with a share capital of £400,000, and an authorized debenture capital of £700,000. A contract for the construction of the works was entered into, but many obstacles had to be overcome before the preliminaries were finally arranged; but eventually, in September, 1888, work was commenced. Since then it has been carried on with as much dispatch as possible. It was expected that the whole undertaking would have been completed in the autumn of 1891, but there were unexpected delays, and the company became embarrassed. This was not the result of extravagant expenditure or incompetent administration.

With regard to the character of the works, we may say that a basin for vessels is being constructed at the Bay of Fundy end 500 ft. long, 300 ft. wide, with a gate 60 ft. wide and 30 ft. high, to enclose the water when the tide is out. At the inner end of this basin there is to be a lifting dock 230 ft. × 60 ft. of first-class masonry. The dock will contain 20 hydraulic presses for lifting vessels with their cargoes a height of 40 ft. Vessels will be brought in if the tide permits and admitted to the dock. They will afterward be floated into position between the hydraulic presses, and immediately over what is termed a "gridiron" and cradle sunk to the bottom of the dock. When a vessel is in her proper position the gridiron and cradle will be gently raised to her bottom. The gridiron with the vessel and cradle will be lifted by hydraulic lifts until the rails supporting them are brought up to the level of those on the railway. Vessel and cradle, resting on wheels, will then be hauled off by a hydraulic apparatus to the railway line. The extreme weight which it is proposed to provide machinery to lift is 3,500 tons, including gridiron, cradle, and a loaded vessel of 2,000 tons displacement, or 1,000 tons register.

A double track railway, 17 miles long, in a perfectly straight line, and almost on a dead level, the heaviest gradient being 1 in 500, is being laid. The rails are of steel, 110 lbs. to the yard. The vessel will be carried on the rails by the same cradle which received her in the lifting dock. It will be carried on a large number of wheels so that the weight of the load will be well distributed, each wheel sustaining but a small portion of the burden. Vessel and cradle will be drawn by locomotives, one on each track, which are calculated to move the load with ease at the rate of 10 miles an hour.

When transported to the other end of the railway, vessel and cradle will be placed on another hydraulic lift while the locomotives are shunted out of the way. It will then be only necessary to lower the vessel to a sufficient depth to enable it to float away, the time occupied in raising, transporting and lowering the vessels will, it is computed, be about two hours. Sufficient rolling stock and transversers will be provided to enable the vessels to be carried by rail at short intervals.

The general prospects of the undertaking, from a commercial point of view, are most satisfactory. The coasting trade round Nova Scotia represents in round figures more than 12,000,000 tons a year, while the annual increase is estimated at 500,000 tons. The number of vessels leaving ports in the Gulf of St. Lawrence, Prince Edward's Island, and the Bay of Fundy, in the year ended June, 1890, was 70,000. It is believed that of this immense trade the Chignecto Ship Railway will receive the largest share. Had the utility, as well as the practicability of the enterprise not been fully demonstrated, the Government of Canada would never have committed itself to the subsidy. It is to be hoped that the Chignecto Marine Transport Company may achieve the success which an undertaking so useful and so important deserves.—*Transport.*

THE MOTION OF FLOWING WATER.

A CORRESPONDENT of *Indian Engineering* calls attention to the peculiar spiral movement of flowing water. He writes: "This phenomenon was noticed by me *in a large deltaic river* on which I was deputed to take flood observations in 1890, and I then made several experiments with a view to drafting

and publishing some formulæ regarding it, as it appeared very remarkable that it should have been so long ignored. And I would point out that this spiral motion occurs *in every channel*. When the stream is wide, or when its depth is very small compared with its width, the water divides into a series of spirals —*between* which silt is deposited. In such cases the motion of the riparian spirals is often such that floating matter is cast off on the sides, instead of being drawn into the center of the stream, and then the channel is silting on its banks. These different movements all bear intimate relations to the mass and shape of the water, the slope and resistance of the soil, etc., and afford great scope for mathematical determination, especially with regard to the neutral condition when the twist of the spirals is being changed and their action is a minimum. The knowledge of these movements is also of great value, not only for engineering works, but also for saving life, as when a man falls overboard it enables one to go to the right place to look for him, and ignorance of this fact explains why so many cases occur of persons falling into a stream and never being seen to rise again.

"The phenomenon, moreover, is universal, and occurs not only in rivers and channels, but also *in oceanic currents*, and even in astronomical nebular, the spiral forms of which it beautifully explains."

FOUR-THOUSAND-TON HYDRAULIC FORGING PRESS.

The Bochum works, in Germany, employ hydraulic presses on a large scale for forging steel ingots, the most powerful being capable of exerting a pressure of 4,000 tons. The machine has a central piston of two different diameters, the lower part being 36.6 in. and the upper 20.87 in., so that it is possible, with a water pressure of 9,000 lbs. per square inch, to secure the pressures of 1,300, 2,700 and 4,000 tons respectively. The stroke of the piston is 3.28 ft., but can be varied at will. The return stroke of the main piston is accomplished by means of two other pistons of 10.24 in. diameter worked by a water pressure of 750 lbs. per square inch. These pistons also serve as guides to the first-mentioned one. The whole machine is made of cast steel. The main cross-head, which is in two pieces, weighs 64 tons; the cylinder weighed 57 tons in the rough and 35 tons finished.

The machine is operated by a valve which is moveable by hand-lever, whose total displacement is but 23⅝ in., and which only requires an exertion of 4 4 lbs. for its manipulation, as it is only subjected to a pressure of 750 lbs. per square inch, this valve sends the water under this pressure to the pistons, which act as valves for admission and exhaust. The stroke of this valve may be divided into three parts: the first opens the exhaust; the second the admission of water at 750 lbs. pressure, and the third that of water at 9,000 lbs. pressure; this last only occurring after the head of the press has come in contact with the ingot to be forged; an arrangement that results in great economy of power.

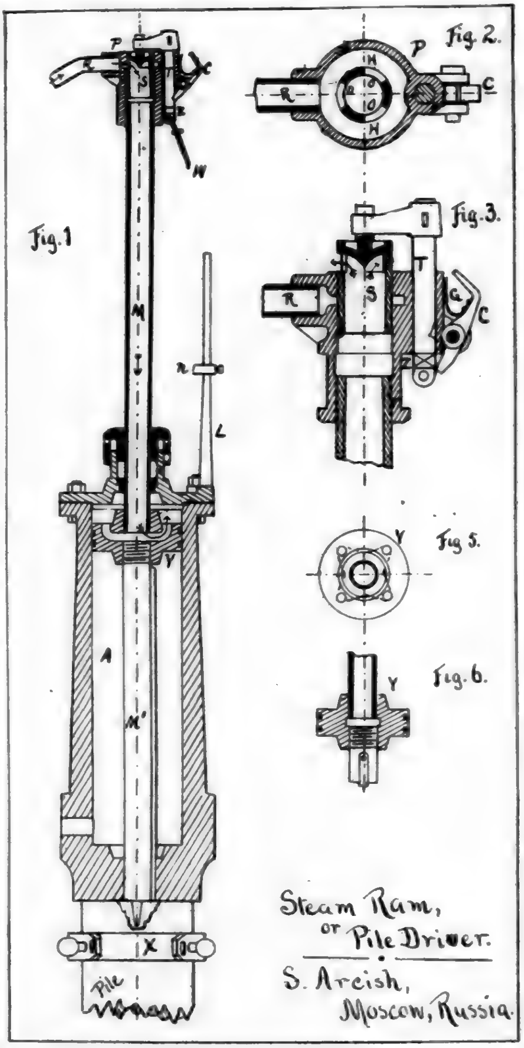
The pressure of 4,000 tons is obtained by a steam pump with two cylinders, each 30 in. in diameter and 47 in. stroke, making 30 strokes per minute. These pumps deliver under a compressed air accumulator whose plunger is 19⅝ in. in diameter, and has a stroke of 8 ft. 10¼ in. The low-pressure water is furnished by a two-cylinder pump, whose cylinders are 18 in. in diameter and 2 ft. 3¼ in. stroke, delivering under a weighted accumulator whose plunger is 21 in. in diameter and has a stroke of 9 ft. 10 in. All of these machines, including the accumulators, are in duplicate, to avoid delays due to possible accidents. The press is located in the center of a circular workshop 108 ft. in diameter. Its top serves as the pivot for a radial crane having a capacity of 275 tons, with the outer end of its jib carried upon a circular track. The furnaces are placed about the walls in two tiers, and are provided with various lifting appliances worked by an accumulator giving a pressure of 750 lbs. per square inch.—*Moniteur Industrielle*.

A RUSSIAN STEAM PILE-DRIVER.

The accompanying illustrations show a new steam ram or pile-driver, devised by Mr. S. Arcish, C.E., of Moscow, Russia. Fig. 1 is a longitudinal section; figs. 2 and 3 show the steam chest and valve on a larger scale; fig. 4 is a side elevation; the remaining figures show various details. It is a simple and cheap contrivance.

A very heavy cast-iron cylinder, *A*, forms the ram, and is guided in its upward and downward motion by two rods, *M* and *M'*, which are fastened to the piston *Y*. The rod *M'* has at its lower end a sharp point which is driven into the top of the pile; the latter is held in place between the upright posts of the pile-driver by the collar *X*, which is secured as shown in figs. 1, 4 and 8. The upper rod is held by the collar *X'*, figs. 4 and 9, so that the whole is supported by the pile and can move only as guided by the posts *N N*, fig. 4.

The upper rod *M* is hollow, and steam passes through it to and from the cylinder. The steam chest, as shown in figs. 1, 2 and 3, consists of a hollow cylinder, *P*, into which the upper end of the rod *M* is screwed. The steam is brought to it through the pipe *R* and passes through the annular channel shown in figs. 2 and 3, to the three openings *O O O* of the circular valve *S*. This valve is connected by an arm with the rod *T*, which moves up and down through a circular hole in a lug cast on the steam-chest. On this lug is placed a catch, *C*, held



by a pin; this catch is kept out by the spring *G* in a position where it engages in recesses made in the rod *T*.

The operation of the ram is as follows: When it has been secured in place, and the operator wishes to begin, the valve *S* is drawn down into the position shown in fig. 1. Steam enters the valve through the annular channel, passes down through the pipe *M* into the cylinder *A* above the piston, and raises the cylinder until the lug *n* on the rod *L* strikes the catch *C*, throws it back, and frees the rod *T*. The valve will then at once rise into the position shown in fig. 3, leaving a clear opening for the exhaust, and closing the annular steam-port, and the ram will fall on the head of the pile. As the

ram falls, the catch C being no longer held up by the collar n, will permit the valve to fall back into its first position, and steam will again be admitted to raise the ram. It will be seen that the piston Y remains stationary, the cylinder A moving up and down. The pile receives the blows of the ram, and the whole machine gradually descends with it, being kept upright and guided by the posts N N.

When the pile is driven nearly to the limit, and will move but slightly under each blow of the ram, the slide-valve will not move quite far enough to admit the steam; it must then be operated by the cord W. This is not difficult, however, and a practised operator can do it without decreasing the number of blows, which is usually about 40 per minute.

To stop the automatic working or lessen the force of the blow, the ports can be closed at any time during the stroke by the cord W. To decrease the stroke, when that is desired, it is only necessary to change the position of the collar n on the rod L, which is easily done.

Steam is carried to the cylinder by the pipe R and its connections, which are usually iron and rubber pipes.

Where sheet piles are to be driven, a collar of the form shown in fig. 7 is used.

Three years' experience has shown that with this machine a pile can be very quickly driven. The time, of course, varies with the nature of soil, weight of cylinder, etc.

The cylinders have been made of three sizes, weighing 1,800 lbs., 2,160 lbs. and 2,880 lbs., the stroke varying from 36 in. to 42 in. The size most used has a ram weighing 2,160 lbs., and a stroke of 3 ft. The total weight of this machine is 4,100 lbs., and it costs, in Russia, $500, with the fittings; the latter including collars for round and sheet piles, 70 ft. of iron pipe, two sets of rubber joint-pipes, and four rollers for moving the pile-driver frame as needed. This size requires an 8-H.P. boiler carrying from 50 to 60 lbs. pressure. It is thus shown to be a machine of moderate cost.

A larger type was recently made and sent to the Oussouri Division of the Siberian Railroad, where it is to be used in driving large iron tubular piles. This has a ram weighing 3,000 lbs., with 3 ft. 6 in. stroke; the total weight is 4,800 lbs., and the cost, in Russia, about $600. This ram requires a 10-H.P. boiler to furnish steam.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 86.*)

At the Paris Exposition of 1889, Commandant *Renard*, of the French Aeronautical Department, exhibited, in connection with the dirigible war balloon "La France," an apparatus which he had designed some years before (1873) as embodying his conception of a flying machine, and which he termed a "dirigible parachute."

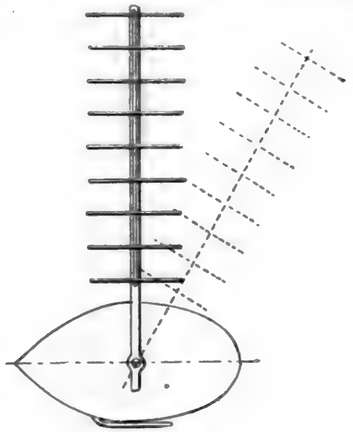
This is shown in fig. 64, and consists in an oviform body, to which is pivoted a couple of standards carrying a series of narrow and long superposed flat blades, intended to sustain the machine when gliding downward through the air.

The dotted lines in the side view indicate the maximum angle of inclination which it was proposed to give to this similitude of a Venetian blind, and it is evident that by setting it at the proper angle, and dropping the apparatus from a balloon, it can be made to travel back against the wind a considerable distance, and also that it may be steered laterally by the addition of a rudder. Beneath the body a sort of skate will be noticed, probably intended to glide over the ground in alighting, or in obtaining initial velocity to rise should a motor be applied; but the French War Department is reticent concerning its experiments in aerial navigation, and the writer has been unable to gather any information concerning the working of this apparatus.

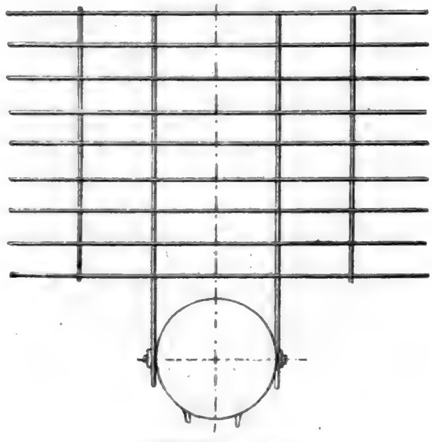
It will be noted that Commandant *Renard* proposed to equip this machine with flat blades, thus conforming to the predilection in favor of plane surfaces exhibited by most of the experimenters with aeroplanes already noticed except Captain *Le Bris* and M. *Goupil*, who took a different view as to the best shapes to employ. In point of fact, as already intimated, those who have succeeded in the air, the true experts in gliding, the soaring birds, do not perform their evolutions with plane surfaces. Their wings are more or less convex on top and concave beneath, and are warped surfaces of complicated outlines. It is true that in many cases they do not differ greatly from planes, and the mind of man so strongly tends to the simplification of complicated shapes, that most inventors have assumed that the effect on the air will be practically the same.

Flight is possible with flat planes, as witness the butterfly, the dragon fly, and insects generally, but such creatures are endowed with greater relative power, as already explained; and, moreover, the elasticity of their wings produces change of shape under action. In the case of the birds, although the outer ends of the feathers are elastic, yet the wing is stiffer as a whole, and the curved surfaces may prove more efficient than planes in obtaining support from the air.

This view seems to have prevailed with Mr. *H. F. Phillips*, for he patented, in 1884, a whole series of curved shapes,



SIDE ELEVATION.



END ELEVATION.

Fig. 64.—Renard—1889.

intended to be used in conjunction with suitable propelling apparatus for raising and supporting an aerial machine in the air. These shapes were to be utilized in a set of narrow blades arranged at suitable distances apart; the idea being to deflect upward the current of air coming into contact with their forward edges when under motion, so as to cause a partial vacuum over a portion of the upper surface of the blade, and thus to increase the supporting effect of the air pressure below the blade.

These shapes were the result of a series of experiments tried by Mr. *Phillips* in artificial currents of air, produced by induction from a steam jet in a wooden trunk or conduit, and described in London *Engineering* in its issue of August 14, 1885.

A cross section of the shapes patented will be found on fig. 65, Nos. 1–8. The following table gives the results observed, the last column having been added by myself:

PHILLIPS'S EXPERIMENTS ON SHAPES.

Description of Form.	Speed of Air Curr'nt. Feet per Second.	Dimensions of Forms—Inches.	Lift Ounces.	Thrust Ounces.	Feet Pounds per Pound.
Plane...........	39	16 × 5	9	2.	8.67
Shape 1........	60	16 × 1.25	9	0.87	5.80
" 2........	48	16 × 3	9	0 87	4.64
" 3........	44	16 × 3	9	0.87	4.25
" 4........	44	16 × 5	9	0.87	4.25
" 5........	39	16 × 5	9	0.87	3.77
" 6........	27	16 × 5	9	2.25	6.75
Rook's Wing...	39	0.5 sq. ft.	8	1.00	4.87

The intent of these experiments seems to have been to ascertain the speed of current required to sustain various forms and areas of surfaces, carrying the same weight in a soaring attitude. For this purpose they were exposed to the varying current with their long edges transversely thereto, and they were loaded with a weight applied one-third of the width back from the forward edge, which point was thought to be the center of pressure. These shapes were swung by two wires attached to their front edges, and when they assumed a soaring attitude in the velocity of current required to sustain the weight, the "thrust" or drift was then measured.

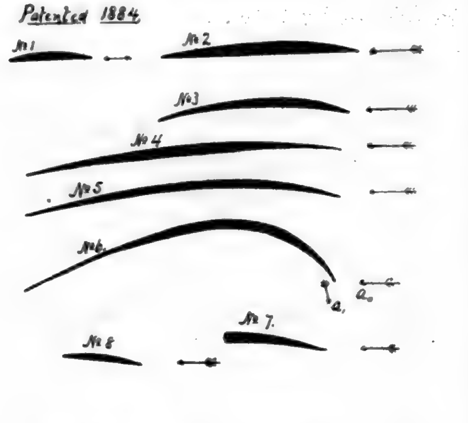


FIG. 65.—PHILLIPS—1884–1891.

The most efficient shape is, of course, that which requires the least expenditure of power, or the smallest number of foot-pounds per pound of weight to keep it afloat, and this is seen to be shape No. 5, which soared with 3.77 foot-pounds per pound, or at the rate of 146 lbs. sustained per horse power, while the flat plane absorbed more than twice as much power.

The comparison would have been more satisfactory if the soaring angles of incidence had been stated. This is given for the plane only as having been 15° by measurement. This agrees fairly well with calculation; for if the "thrust" is to the "lift" as the tangent of the angle of incidence, then we have $\frac{2}{9} = 0.222 =$ *tang.* 12° 32'. But all the results obtained were probably somewhat vitiated by assuming that the center of pressure was uniformly one-third of the distance back from the front edge, and therefore applying the load at that point.

We have already seen that this center of pressure varies with the angle of incidence in accordance with Joëssel's law, and the load should have been attached accordingly. If, for instance, the possible soaring angle were 4°, we should have for the position of the center of pressure, back from the front edge, a distance of $0.2 + 0.3$ *sin.* $4° = 0.22$ per cent. So that it seems probable that if its load had been applied at 22 per cent. instead of 0.33 per cent. back from the front edge, the flat plane would have soared at a flatter angle than 15°, and would have shown less "thrust," because the effect of placing the weight so far back was to tilt the plane unduly, and thus to increase both the angle of incidence and the thrust.

It is not known whether Joëssel's formula applies to curved surfaces; but be this as it may, it is reasonable to believe that it would be but little modified, so that perhaps the error in locating the center of pressure operated to the disadvantage of the curved forms nearly as much as to that of the plane. We may, therefore, accept the general statement that greater weights per horse power can be sustained in the air with concavo-convex surfaces than with flat planes; but it seems very desirable that further experiments should be made, for it is quite possible that, in consequence of the loading of the blades at a point differing from the center of pressure, the shapes patented by Mr. *Phillips* are not absolutely the most efficient forms.

It will be interesting, in this connection, to note how these various shapes behaved. It was found that in order to get the maximum efficiency from any given surface, the greatest depth of hollow should be one-third of the total width from the forward leading edge, and that the amount of concavity of the lower surface and the convexity of the upper surface should bear a relation to the speed of the air current. Thus in shapes 1 and 2 the under surface was nearly flat, and the upper curvature not great, while speeds of current of 60 ft. and 48 ft. per second were required respectively to produce a soaring attitude. In shape 3 the curvature was more marked, and the required speed fell to 44 ft. per second. Shapes 4 and 5 were made broader, with a moderate degree of curvature both above and below, and the speeds of current to produce soaring were 44 ft. and 39 ft. per second respectively. Shape 6 was an extreme case, in which the distinguishing features of the experiments were purposely carried to excess; for when impinged upon by a current of air of 27 ft. per second in the direction of the arrow a_0, it was seen (by a fine attached ribbon) that there was an induced current flowing outward in the direction a.

Shapes 7 and 8 were used to demonstrate that the impinging air is deflected upward by the forward part of the upper surface, and that a partial vacuum results in the after part; they were not loaded with weights, and when exposed to a current of air of sufficient velocity, coming in the direction of the arrow, they rose into the position shown in the figure.

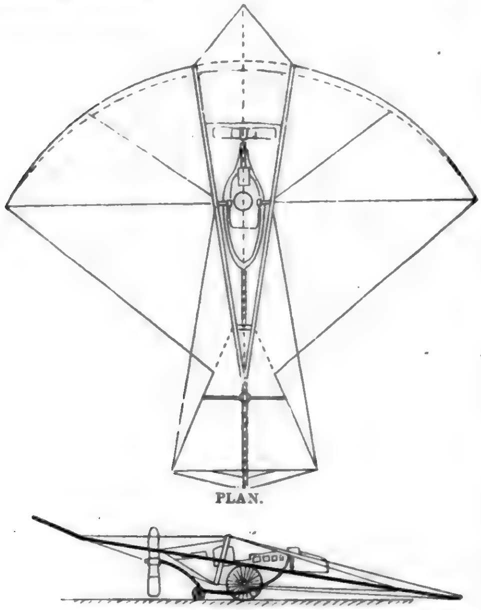
In 1890 Mr. *Phillips* patented an aerial vehicle in which these curved surfaces were applied to an apparatus similar to the "dirigible parachute" of Commandant *Renard*, except that there were to be two (or more) series of curved blades behind each other at suitable distances apart. They were to be attached to an elongated body, which he indicated might be of fish shape, and, say, 30 ft. long. The cross-blades, which he termed "sustainers," might be 15 ft. long, 6 in. wide and 2 in. apart, so many being superposed as to furnish the required supporting air surface. Each set of "sustainers" was to be held in place by a number of vertical bars of angular form, so as to offer the least resistance to the air.

The propelling power was not indicated specifically, save the general statement that it should be "suitable," but a rudder was located at the top of the front series of curved blades, being affixed to a spindle bar terminating below (at the body) with a lever arm. A shifting weight was also provided, capable of being moved across the body, transversely to its line of motion, in order, when moved to either side, not only to depress it, but, by the resistance of the air acting on the surface of that weight, to check forward motion on that side, and thus cause the machine to describe the curve required.

The patent drawings show the vertical standards carrying the blades as being rigidly attached to the body instead of being pivoted thereto, as in the case of Commandant *Renard's* device, and hence the angle of incidence of the machine could not be conveniently varied in order to rise or to descend; but it is probable that Mr. *Phillips* has long since remedied this defect, for he is understood to have been continuously experimenting, although the results attained have not as yet been published.

He apparently concluded that he had not developed the best shape in 1884, for he patented, in 1891, the form shown at the bottom of fig. 65. In this, the upper side *A* of the blade was made convex, as formerly, but the after portion of the lower side of the blade was made concave, as shown at *B*, while the curvature of the forward portion of this lower side was in the form of a reverse curve consisting of a convex curve, *C*, at the forward edge, followed by a concave curve, *D*. He states in his patent:

"The particles of air struck by the convex upper surface *A* at the point *E* are deflected upward, as indicated by the dotted lines, thereby causing a partial vacuum over the greater portion of the upper surface. The particles of air under the point *E* follow the lower convex and concave surface *C D* until they arrive at about the point *G*, where they are brought to rest. From this point *G* the particles of air are gradually put into motion in a downward direction, the motion being an accelerating one until the after edge *F* of the blade is passed. In this way a greater pressure than the atmospheric pressure is produced on the under surface of the blade."



PLAN.

SIDE VIEW.

FIG. 66.—GRAFFIGNY—1890.

Mr. *Phillips* indicates that such blades may be of wood, 12 ft. in length and 6 in. in width, from the leading edge *E* to the rearward edge *F*, but he does not state what distance they should be apart vertically, having probably ascertained that if spaced 2 in., as formerly proposed, they will interfere with each other. He intends, presumably, to adopt this shape for the slats or blades of the Venetian blinds of his proposed apparatus, when he has worked out to his liking the remaining features, such as the motor and the propeller, the safest modes of rising and of alighting, the best way of shifting the center of gravity so as to correspond with the center of pressure at all angles of incidence, etc.; but whether he succeeds in this or not, he is entitled to great credit as having been among the first to experiment with other than plane surfaces, and having shown that greater sustaining power can be obtained with wing-like concavo-convex surfaces than with planes, thus drawing attention to what may prove to be an important line of inquiry.

Almost all scientific experiments in air have hitherto been tried with planes, and such few formulæ as have been proposed are based upon the effect on flat surfaces. It is probable that such formulæ—those of Smeaton, Duchemin, Joëssel and others—will be found to need modification, either in form or in constants, when applied to curved surfaces. In such case the tables of "lift" and "drift" heretofore given herein will either need recalculation for each specific curved shape, or require the application of a variable coefficient, as exemplified in the calculations of the power expended by the pigeon as heretofore given. In any case it seems very desirable that further scientific experiments be made on concavo-convex surfaces of varying shapes, for it is not impossible that the difference between success and failure of a proposed flying machine will depend upon the sustaining effect (with a given motor) between a plane surface and one properly curved to get a maximum of "lift."

Fig. 66 represents a kite-like aeroplane proposed by M. *de Graffigny*, a French aeronaut, and the author of several works upon aerial navigation. This apparatus was to consist of a kite 46 ft. across, with its fabric surface capable of bagging to a certain extent, and attached to a longitudinal frame, as shown, which was to be trussed both above and below. In front, a stiff triangular head was to be affixed, and an adjustable horizontal tail was to be placed in the rear. Between these a boat-shaped body containing the machinery and aviators was to be swung on trunnions and attached to the frame. In front of this car a two-armed screw was to rotate, and behind the car a vertical steering rudder was to be placed, above the surface of the kite.

M. *de Graffigny* estimated that the power required to drive the apparatus was in the proportion of one horse power for every 110 lbs., and he proposed the use of liquefied carbonic acid gas, which he states to weigh but 55 lbs. per horse power, including the motor, the recipient and a supply for several hours. This, of course, was a mere makeshift, a reservoir of power for experiment, and not a prime mover; inasmuch as the whole apparatus was to weigh but 396 lbs. and to have sufficient sustaining surface (some 1,300 sq. ft.) to come down like a parachute, should the motor break down while in the air. The screw was to be 6 ft. in diameter and 10 ft. pitch, and its shaft was to remain constantly horizontal (this being the object of hanging the car on trunnions), so that the position of the propeller should be independent of the angle of incidence of the sustaining surface in accordance with the theory of the designer.

M. *de Graffigny* states that he experimented with a model of this apparatus in 1890. The screw was rotated some 300 turns per minute by a skein of twisted rubber threads weighing, in the aggregate, 1.1 lbs., and producing 1,085 foot-pounds in 2½ minutes, or at the rate of 7.23 feet-pounds per second, which proved quite insufficient to give to the apparatus (mounted on three wheels, the foremost of which was adjustable) the velocity necessary to cause it to rise upon the air. The designer expresses himself as unable to state what would be the result with a full-sized apparatus.

It will be noted that this proposal resembles a number of others which have already been described. It is probable enough that the best form for sustaining a given weight and for propelling it with a minimum of surface and of power, or for maintaining equilibrium, have not been selected; but M. *de Graffigny*, in the book * in which this design is incidentally described, strongly advocates the kite principle generally, as the one most likely to lead to success in devising a flying machine, and in learning how to manage it in the air.

This will have occurred to many readers, and it may be interesting to them to inquiry as to what has been published upon past experiments with kites, a subject upon which the writer has found distressing little on record.

Among the first, if not the very first, to call attention to the fact that the study of the kite as a means of obtaining

* "Traité d'Aérostation." H. de Graffigny, 1891, p. 189.

unlimited lifting and tractive power had been unduly neglected was Mr. *Wenham*, who, in his celebrated paper on "Aerial Locomotion," published in 1866, described briefly some very interesting experiments with kites, and who has kindly furnished the writer with some additional particulars. Mr. *Wenham* states that his principal summary of facts was taken from a little book, styled the "History of the Charvolant, or Kite Carriage," by Mr. *George Pocock*, of Bristol, England, who also published a small work on "Aeroplastics," both of them, unfortunately, now having become very rare.

The experiments described took place more than half a century ago, and the purpose of the inventor was not to evolve a flying machine, but to provide a floating observatory to serve in warfare, or to drag wheeled vehicles over land.

The apparatus was, in fact, a huge kite, of suitable size to carry the intended weight, with a chair swung just below, and so rigged that by tightening or slackening the different cords which held it, the wind would meet it at any angle desired, and the apparatus would rise or fall, or could be made to swing a considerable distance to one side or the other. It was so arranged that in case the cords broke, it would act like a parachute, and thus insure safety.

The following quotation, descriptive of the experiments, was given by Mr. *Wenham* in his paper :

"While on this subject we must not omit to observe that the first person who soared aloft in the air by this invention was a lady, whose courage would not be denied this test of its strength. An arm-chair was brought on the ground, then lowering the cordage of the kite by slackening the lower brace, the chair was firmly lashed to the main line, and the lady took her seat. The main brace being hauled taut, the huge buoyant sail rose aloft with its fair burden, continuing to ascend to the height of 100 yards. On descending she expressed herself much pleased with the easy motion of the kite and the delightful prospect she had enjoyed. Soon after this another experiment of a similar nature took place, when the inventor's son successfully carried out a design not less safe than bold—that of scaling, by this powerful aerial machine, the brow of a cliff 200 ft. in perpendicular height. Here, after safely landing, he again took his seat in a chair expressly prepared for the purpose, and, detaching the swivel line, which kept it at its elevation, glided gently down the cordage to the hand of the director. The buoyant sail employed on this occasion was 30 ft. in height, with a proportional spread of canvas. The rise of the machine was most majestic, and nothing could surpass the steadiness with which it was manœuvered ; the certainty with which it answered the action of the braces, and the ease with which its power was lessened or increased. . . . Subsequently to this an experiment of a very bold and novel character was made upon an extensive down, where a wagon with a considerable load was drawn along, while this huge machine, at the same time, carried an observer aloft in the air, realizing almost the romance of flying.

"It may be remarked (continues Mr. *Wenham*) that the brace lines here referred to were conveyed down the main line and managed below ; but it is evident that the same lines could be managed with equal facility by the person seated in the car above ; and if the main line were attached to a water-drag instead of a wheeled car, the adventurer could cross rivers, lakes, or bays with considerable latitude for steering and selecting the point of landing, by hauling on the port or starboard brace-lines as required. And from the uniformity of the resistance offered by the water-drag, this experiment could not be attended with any greater amount of risk than a land flight by the same means."

The reader may perhaps inquire whether there was not some risk that the kite should run away with the wagon when the wind freshened ; but Mr. *Wenham* further explains that the kite attached to the "charvolant" or chariot was provided with a smaller "pilot," or upper kite, which was sufficient to support the "draft," or lower kite, when it was relaxed or allowed to float edgewise, on the wind. The "draft" kite had two cords, one attached well forward, and the other attached well aft, running through rings to keep the cords together. If the aft cord was slacked off by the driver of the chariot, the "draft" kite floated edgewise on the wind, and the wagon stopped ; but by pulling on the aft cord the kite could be made to face the wind absolutely, and to produce the maximum of draft.

Mr. *Wenham* also mentions in his paper Captain *Dansey's* kite, for communicating with a lee shore, as described in Vol. XLI. of the "Transactions of the Society of Arts." This was made of a sheet of holland fabric exactly 9 ft. square, and, as stretched by two spars placed diagonally, spread a surface of 55 sq. ft., the remarkable fact about its performance being that in the experiment about to be quoted this surface of 55 sq. ft. sustained no less than 92½ lbs. The quotation is as follows :

"The kite, in a strong breeze, extended 1,100 yards of line ¾ in. in circumference, and would have extended more had it been at hand. It also extended 360 yards of line 1½ in. in circumference, weighing 60 lbs. The holland weighed 3¾ lbs., the spars, one of which was armed at the head with iron spikes for the purpose of mooring it, weighed 6¾ lbs., and the tail was five times its length, composed of 8 lbs. of rope and 14 lbs. of elm plank, weighing together 22 lbs."

This latter kite seems to have been provided with a tail to steady it in the air, and in considering the bearing of such experiments upon possible flying machines, it is preferable to select those upon tailless kites, sailed with one single line, for it is easy to maintain the stability if several restraining cords be used. Mr. *Wenham* has kindly furnished to the writer the particulars concerning a tailless kite, or, rather, series of superposed kites, patented in Great Britain in 1859, by *E. J. Cordner*, an Irish Catholic priest, who designed the apparatus to save life in shipwrecks, and who preferred to arrange hexagonal disks of fabric (stretched upon three sticks), above each other on the same line, so that they would all pull together. The operation was to be as follows :

When a sailing vessel had struck, which almost in every case occurs by the ship being blown on a lee shore, a common kite was to be elevated in the usual way from on board the vessel. When enough cord had been paid out to keep the kite well suspended, the end of the cord on board was to be attached in a peculiar manner to the back of another and larger kite (without tail), and the second kite was then to be suffered to ascend. The end of the suspending rope was to be attached in a similar manner to the back of another and still larger kite, and the process to be repeated until enough elevating and tractive power was obtained, when a light boat or basket with one occupant was to be fastened to the kite line, the latter being paid out until the occupant reached the shore and alighted, when by means of a light running line, extending from the ship to the person ashore, it was deemed easy to haul the basket back and forth as many times as necessary to rescue the passengers and crew.

It is not known whether this ingenious method of saving life without extraneous aid was ever used in a case of actual shipwreck, but it was tested by transporting a number of persons purposely assembled on a rock off the Irish coast, one at a time, through the air to the main land, quite above the waves, and it was claimed that the invention of thus superposing kites so as to obtain great tractive power was applicable to various other purposes, such as towing vessels, etc.

Many proposals have been made at various times and in various countries to utilize kites in life saving, but none seem to have come into practical use. Such attempts may have suggested to Mr. *Simmons* (the English aeronaut) the experiments which he is said to have tried, in 1876, of gliding downward under such buoyant sails.

The only accounts which the writer has found of these experiments are given in the *Aéronaute* for April, and for November, 1876. The apparatus of Mr. *Simmons* is described as consisting of a huge "pilot" kite 49 ft. high and 49 ft. wide, with another kite below, still larger. The pilot kite was first to be raised, and to carry up the second ; the two were to be adjusted to the breeze, and the aeronaut was to be suspended in a car, and allowed to ascend 200 or 300 yards. Then by adjusting his weight by means of guy lines, so as to obtain a proper angle of incidence, the apparatus was said to glide downward to the ground, being slightly dirigible through the guy lines, and to be arrested by the bystanders seizing a dragging guide rope.

Mr. *Simmons* is said to have been fairly successful with his experiments in England, but to have failed to repeat the feat at Brussels, Belgium. In the latter case it was claimed

that there was not sufficient wind, but steadiness of breeze would be more important. The surfaces operated with seem to have been very large—some two to three square feet per pound in order to alight gently; but such extent of surface is so unmanageable in a gusty wind as probably to have led to the abandonment of the experiments.

The exploit is feasible, and would prove useful in experimenting with various shapes and extent of surfaces, but such experiments should be tried with areas more nearly corresponding to the proportions which exist in soaring birds, and the operator should invariably alight in water until he has learned how to manage his apparatus.

(TO BE CONTINUED.)

CARE OF FOUNDATION BRAKES.

AT the January meeting of the New York Railroad Club Mr. James Howard read the following paper on the Care of Foundation Brakes:

"The subject which I have proposed for consideration is one that may appear upon the face of it to need but little attention, from the fact that foundation brakes are as old as railroading, and every railway man is supposed to be familiar with them. The necessity of using the term 'foundation brakes,' so far as railroad cars are concerned, came in with the application of power—other than manual—to the old-fashioned brake. It appears that those who furnished the mechanism for supplying the power were not content to describe it as an apparatus for operating the brakes, but whether the power applied was hydraulic, steam, air or vacuum, the brake that did the actual work upon the wheels was appropriated, and although it was the same old brake, it became at once a hydraulic, steam, air or vacuum brake, according to the respective manufacturers; yet what these manufacturers supply is in no sense a brake, but merely an apparatus for supplying the power whereby the old brake is operated. I call attention to this feature because it has been the means of eclipsing the importance due to foundation brakes; for instance, the adoption of the air-brake has rendered it necessary to establish schools of instruction with elaborate sets of apparatus, test stations, inspectors, etc. Rules have been formulated, both by the railroad and air-brake companies, all to enforce a knowledge of *the apparatus that supplies the power to the actual brake that does the work*, and so it comes to pass that while there is no lack of printed instructions upon air-brake apparatus, we look in vain for any printed rules for the guidance of those who have the care of the foundation brakes. At the same time we know full well that no matter how perfect the air-brake apparatus may be, if the foundation brakes are defective there is no brake upon the train. In fact, so far has this eclipsing process gone on, that it is impossible to find many who are competent to tell you why the air-brake apparatus did or did not do its duty, yet they are puzzled to explain why the train did not stop when it ought to have done so.

"Of late I have had special facilities for observing the condition of foundation brakes, and to say the least it is surprising how widely spread is the inefficiency of these brakes. The knowledge of this fact is the more important because this inefficiency seems to exist in many cases without the knowledge of those in special charge of brakes, and is often brought to light only by some case of emergency. In conversation with a brake inspector upon this subject, he assured me that there were very few who really understood foundation brakes, and fewer still who knew when a foundation brake was in good order, that in fact there were very few trains running with all their brakes in perfect order. 'You see those cars over there,' he said, pointing to several sidings full of passenger cars, 'I can assure you that not one of those cars has a perfect brake upon it.' I have since learned that this testimony might be duplicated on other roads; so general is it that my experience teaches me that the somewhat hackneyed expression, 'the air-brakes failed to work,' would be nearer the truth if changed to 'the foundation brakes failed to work.' I lately saw a train of coaches, in a yard test; the brakes upon these coaches showed 6 in. of piston travel, but out on the road, under an emergency application, the full stroke of the piston was exhausted and the brake pistons were dead against the cylinder-heads. The trucks under these coaches were the ordinary four-wheeled swing-beam trucks with wooden brake-beams trussed with ⅞-in. rods. There was ⅜ of an inch clearance between the friction plates upon each side of the truck transoms. Each of the axle-boxes and pedestals showed from ¼ to ⅜ of an inch clearance upon each side. The center-plates and king-bolts were worn so that it was not difficult to see that even if the brake rigging itself were in perfect order all this free slack must be taken up before there could be any application of the brake-shoes to the wheels, and the reason why these brakes only showed 6 in. of piston travel when tested by an ordinary service application, and exhausted the full piston stroke on an emergency application, was because a service application afforded sufficient power to take up a certain amount of this slack and apply the brakes, while in an emergency application, owing to the free slack in the pedestals, truck transoms and center-plates, the truck wheels were drawn closer together and the trucks themselves were drawn bodily toward the center of the car; add to this the deflection of the wooden brake-beams and the exhaustion of the piston stroke is sufficiently accounted for. In this case the only fault in the brake-rigging was the weakness of the brake-beams, and the sooner wooden brake-beams are exchanged for steel or iron, the better. In other respects the air-brake apparatus and the foundation brake-rigging did its work, but the condition of the trucks rendered the whole brake defective.

"By far the larger amount of inefficiency in foundation brakes arises from the bad adjustment and incorrect spacing of levers and rods. There is still a large amount of brake-rigging in use that does not come under the Master Car-Builders' standards. Some of this is out of all proportion to the work required of it. Cylinder levers of ⅞ iron, the pin holes in which are spaced 9¼ in. and 11¼ in. respectively, even supposing this was correct for the amount of power required, yet to give the end of a lever a 9¼-in. fulcrum that may be called upon to make a 10 or 11-in. stroke is open to criticism. There are quite a number of coaches that have such levers in their brake-rigging; with such levers it does not take a very large accumulation of slack before cramping takes place. Another source of inefficiency is found in the manner in which the brakes are hung. Brake-shoes should be hung as nearly as possible upon a line with the center of the axles. Some are hung so low down upon the wheels that not only is the truck twisted out of shape every time the brakes are applied, but the truck levers are by this means kept so low that to couple them with the floating levers the rods are forced out of line, being drawn down over the truck transoms, so that the friction thus produced absorbs a considerable amount of power and the effect upon the brake-shoes is weakened. Then there is the cramping of clevises, caused by an improper set in the jaws, binding of the rods upon the hangers, the absence of stops upon the brakemast chain, the pull rods coupled up unequally. Sometimes one and sometimes all of these faults are present at the same time. I recently saw a mail coach that had its brake so cramped that with the air full on and 6 in. of piston travel there was no pressure upon the brake-shoes. When the pin was knocked out of the cylinder lever the rod sprang back 6 in., and this was on a new modern coach. Rods too long or too short are a constant source of trouble. There is no valid reason why this should be the case. It does not take very long to overhaul a brake to find and cure this trouble, and it will always repay the time spent upon it. I have before, elsewhere, mentioned a method of doing this, which is the best I know of, and as my object in introducing this subject here is that you may follow it up with practical results, I submit it to you for your criticism; doubtless the system mentioned is nothing new, but simply requires more frequent and general use.

"First put on a complete new set of shoes. Uncouple the cylinder levers from the pull-rods. Clamp the brake-beams to the wheels, using a piece of ¼ plate between the shoe and the wheel. Set the truck-levers at their proper angles, then take the length for the bottom rod between the two truck-levers. Set the floating-levers at their proper angles, then measure the length required for the pull rod, which joins the top end of the live truck-lever with the floating-lever. From the other end of the floating lever measure the length required for the hand-brake pull-rod, taking care that this rod has a good, firm stop-bracket and block before it reaches the brake-mast chain. Set the cylinder-levers at their proper angles, usually 60°, and measure the length between them and the floating-levers for the main pull-rods. Then take the length of the space-bar between the cylinder-levers. See that the rods are so hung that they go in direct lines to their work, that they are not deflected over the transoms nor in any way cramped by their clevises or their hangers, that all pins fit well and can be inserted and withdrawn without straining. The ¼ plate is inserted between the shoes and the wheels in order to give the necessary amount of piston travel to pass the leakage groove, and can be varied to meet any desired travel.

"And now allow me again to urge the necessity and importance of doing something in this matter. So far as I am

aware there are at present no written rules for inspectors that cover the vital points in foundation brakes, and none of our brake inspectors are specially instructed in them, nor are their duties in regard to them defined. It would not be hard to draw up a few concise rules to cover the points I have mentioned. The inspector's attention should be drawn to the positions of levers and rods; he should see that there is no cramping in the jaws of the clevises, no binding on the hangers, no undue friction around the floating-levers; that all hand brake-rods have good stops upon them which will relieve the brake staff and chain of undue strain; that rods are not coupled up unevenly; that excessive wear in truck transoms or pedestals and boxes is promptly reported and remedied; that the piston travel is not unduly affected by deflection of parts and is about the same whether a service or emergency application is made. There are other points, no doubt, that will strike those whose duties bring them in contact with this particular branch of railway service, and I hope practical results may follow."

CAR-WHEEL FLANGES.*

The standard distance between the backs of the flanges of car-wheels, which has been recommended by the Master Car-Builders' Association, is 4 ft. 5⅝ in. as shown at *A*, in fig. 1. The same Association has recommended that in fitting wheels on axles a variation be allowed of ⅛ of an inch each way from the standard distance of 4 ft. 5⅝ in. between flanges, making the maximum distance 4 ft. 5¾ in., and the minimum 4 ft. 5½ in., as shown at *A*, fig. 1. This was adopted in 1885.

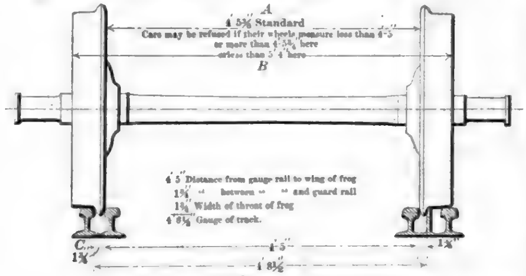


Fig. 1.

It was not, however, until the following year, 1886, that wheel-gauge limits were introduced into the Master Car-Builders' rules of interchange and the present limits adopted. This is rather remarkable when we consider the important part that the wheel-gauge plays in the safety of running cars. Moreover, it was not a new idea; various lines had for years previous to this adopted limits for the distances between and over flanges. Perhaps the real reason for so long evading the question in the rules was the difficulty in reconciling the interests of the roads using a 4 ft. 8½ in. gauge and those using 4 ft. 9 in. As the standard wheel-gauge for 4 ft. 9 in. track

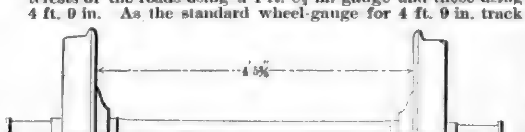


Fig. 2.

and 4 ft. 8½ in. track must necessarily be different, let us consider how it was possible for these two interests to adopt the same limits. First of all, let us understand thoroughly why 4 ft. 5 in. is the minimum limit. Simply because 4 ft. 5 in. is the distance between the guard-rail and wing of frog, both for 4 ft. 8½ in. and 4 ft 9 in. track. In the former case by having 1¾ in. space between gauge and guard-rail, as shown at *C*, fig. 1, and also between the frog point and wing of frog, shown at *D*, and in the latter case, fig. 2, by having 2 in. at the same points. Any wheels measuring less than 4 ft. 5 in. between flanges would have a tendency to either mount the guard-rail, or by crowding its way through bring stresses likely to produce broken axles.

Let us next consider the reasons which make a maximum limit important.

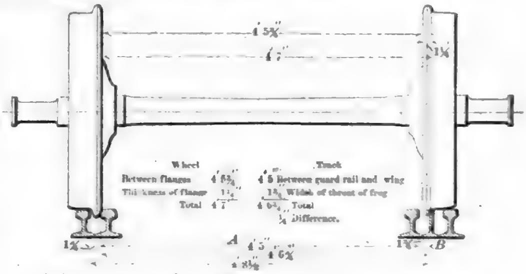


Fig. 3.

Referring to fig. 3 we find:

WHEELS	Maximum between flanges	4'—5¾"
	Thickness of wheel flange (M. C. B. Section)	1¼"
	Total	4'—7"
TRACK 4'—8½"	Distance *A* from guard-rail to wing of frog	4'—5"
	Distance *B* between wing of frog and frog point	1¾"
	Total	4'—6¾"
		Difference, ¼ inch.

This, it will be observed, is not in keeping with good practice, for it allows a wheel mounted to the maximum limit to strike a frog point on 4 ft. 8½ in. track with a full ¼ in. of wheel, and clearly explains why frog points are so difficult to maintain even on 4 ft. 9 in. track. The maximum limit of 4 ft. 5½ in. as originally adopted in 1886 was more in keeping with the usually well-considered actions of the Association. The change to 4 ft. 5¾ in. was made in 1887. Those allowing this to go through either did not understand the importance of the matter, or were considering the interests of the roads using 4 ft. 8½ in. gauge. If we mount wheels beyond a 4 ft.

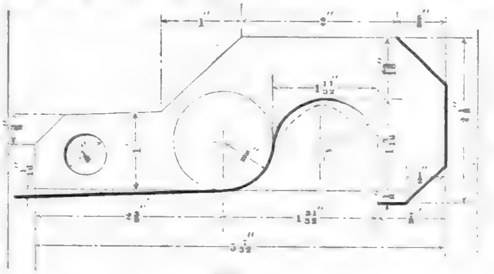


Fig. 4.

5¾ in. limit, the wheel will come with full force against the frog point, not only ruining the point, but if the guard-rail is loose and out of position, or if 4 ft. 5¾ in. is exceeded, there is a strong probability of the wheels taking the wrong side of the frog point and ditching the train.

Let us now consider how this question may be affected by a varying section of wheel. It should be borne in mind that the Master Car-Builders' Association has no maximum flange gauge, although they do have a minimum. In purchasing cast-iron wheels we have at times found such variations in the thickness of flanges, even when the patterns are all identical with that used on the Chicago, Burlington & Quincy Railroad, that we have found it necessary to adopt a maximum as well as a minimum flange gauge for new wheels. (Figs. 4 and 5 represent these gauges.) Flanges that will not take the maximum gauge (fig. 4) are not accepted, and flanges that will take the minimum (fig. 5) are not accepted. The use of these gauges makes it practical in mounting wheels to use a wheel-gauge each end of which is of the form shown in fig. 6, which at once controls the standard Master Car-Builders' limit between flanges of 4 ft. 5½ in., and inasmuch as the flange contour of the wheel-gauge corresponds with our maxi-

* Abstract of a paper by Godfrey W. Rhodes, Superintendent of Machinery of the Chicago, Burlington & Quincy Railroad, read before the Western Railroad Club, January 17, 1893.

mum flange (fig. 4), it prevents the acceptance of any thick flanges should our foundry wheel inspectors accept wheels that they should not. Few railroads, we believe, use either maximum or minimum flange gauges in inspecting new wheels. At a foundry in this immediate neighborhood (Chicago) we recently found wheels being cast and accepted for service with a flange section that exceeds even the Chicago, Burlington & Quincy maximum limit. Foundries do not always appreciate these differences in railroad practice.

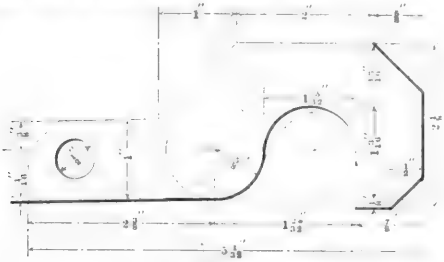


Fig. 5.

Let us consider why with the prevailing practice of mounting wheels there should be uniformity in the thickness of flanges. The Master Car-Builders' standard, as shown in fig. 7, is usually estimated as measuring 1¼ in. through the flange, as at *A* (some would call it 1⅜ in., as at *B*), with the same method of reckoning the thick flange referred to, meas-

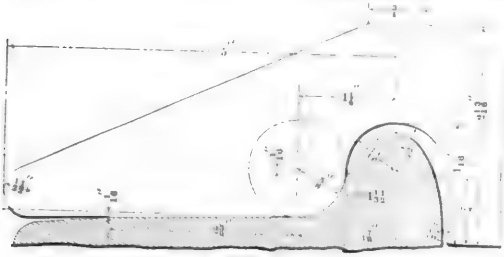


Fig. 6.

ures a strong 1⅜ in. (some would say 1½ in.) The Master Car-Builders' wheel mounted to the maximum standard allowable between flanges measures as follows over flanges :

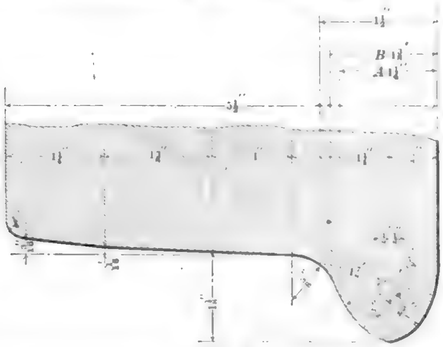


Fig. 7.

Distance between flanges	4'—5½"
Width of one flange	1¼"
Width of one flange	1¼"
Distance over flanges	4'—8"

The above allows ½ in. play on a 4 ft. 8½ in. track. With the 1⅜ in. flange we would have :

Distance between flanges	4'—5½"
Width of one flange	1⅜"
Width of one flange	1⅜"
Distance over flanges	4'—8¼"

Only allowing ¼ in. side play on a 4 ft. 8½ in. track or ⅛ in. on a side. If, however, one chooses to call the thickness of the flange 1½ in. in place of 1⅜, it is apparent that there would be no side play at all on a 4 ft. 8½ in. track.

Let us now consider how such a flange will act on the frog points of 4 ft. 8½ in. track. (See fig. 8.)

Di tance between wheel flanges	4'—5½"	
Width of flange	1⅜"	
		4'—6⅞"
Guard rail and wing of frog	4'—5"	
Wing of frog and frog point	1¾"	
		4'—6¾"
Difference		⅛"

The flange, therefore, would not clear the frog points by ⅛ of an inch or ¼ in., if the flange in question is rated as measuring 1½ in. Suppose, however, that no exception is taken to thick flanges, and that we attempt to mount them to the standard over flanges :

Standard distance between flanges	4'—5⅜"
Standard thickness of flange	1¼"
Standard thickness of flange	1¼"
Present standard over flanges	4'—7⅞"
Width of thick flange	1⅜"
Width of thick flange	1⅜"
Necessitating a change in standard between flanges to	4'—5⅛"
Present standard over flanges	4'—7⅞"

This leaves but 4 ft. 5⅛ in. between flanges, whereas the standard minimum limit (p. 106, 1890 report) is 4 ft. 5¼ in. If, however, we consider our thick flange as measuring 1½ in., we in the same manner will get for distance between flanges 4 ft. 4⅞ in. If we wish to preserve 4 ft. 7⅞ in. over flanges :

Width of flange	1½"
Width of flange	1½"
Distance between flanges	4'—4⅞"
Distance over flanges	4'—7⅞"

There is, however, still another phase of this question to consider. What has been said is based on the assumption that wheels are accurately mounted within the Master Car-Builders' standards. It is well known, however, that in practice accuracy is not always followed ; the interchange rules provide that cars must be accepted if the wheels do not measure more than 4 ft. 5⅝ in. or less than 4 ft. 5 in. between flanges ; with these figures we get the following results with thick flanges. (See fig. 9.)

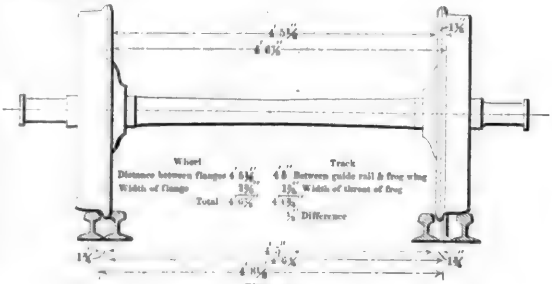


Fig. 8.

With flanges, then, as thick as some foundries are casting them, it is possible to have them mounted within the gauge limits of the Master Car-Builders' interchange rules and still not have them clear the frog points of 4 ft. 8½ in. track by ⅛ of an inch, if we rate flanges at 1⅜ in. thick and ¼ in. if we call them 1½ in., and in the case of 4 ft. 9 in. track they would just clear the point with 1⅜ in. flange and strike it with ⅛ in. of wheel, if rated as a 1½ in. flange.

It would, therefore, seem that the thickness of wheel flanges plays an exceedingly important part in the consideration of this question. With the present limits between flanges, as prescribed by the interchange rules, and with no limits whatever for a maximum thickness of flange, a very dangerous and expensive element is quietly being introduced under the rolling stock throughout this country. It is our opinion that a maximum flange gauge should be considered at once by the Master Car Builders' Association, and in adopting the same full consideration should be given to the present wheel gauge limits. There is hardly a month passes on any of the through trunk lines that we do not hear of cars mysteriously leaving the rails. Is it to be wondered at with flanges and gauge limits as outlined in this paper ?

In Mr. R. H. Soule's admirable collation of Master Car-Builders' standards presented at the last Master Car-Builders'

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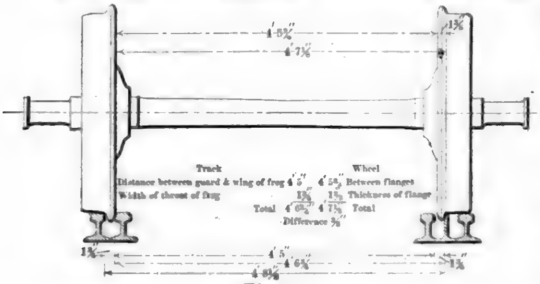

Fig. 9.

the inexcusable state of affairs represented in fig. 10. The track foreman had evidently been endeavoring to save the wear on his frog points without considering any other phase of the question. It will be noticed the distance between guard-rail and wing of frog is actually 4 ft. 5⅜ in. It will be thus seen that on the assumption that the wheels were gauged strictly to the Master Car-Builders' standard of 4 ft. 5⅝ in. between flanges, they would not clear the wing of frog by ⅛ of an inch even on the supposition that the flanges conformed to the Master Car-Builders' standard. If, however, the wheels

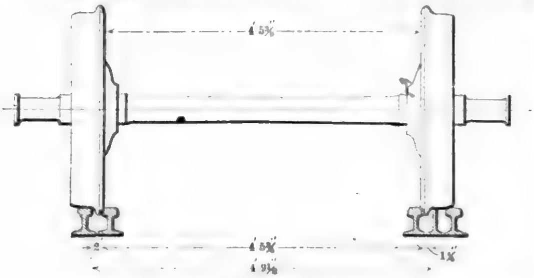

Fig. 10.

were gauged only to the interchange rule minimum limit of 4 ft. 5 in., they could not clear such a condition of track by ¾ in. It seems almost incredible that such a condition of things could exist on a first-class railroad. The facts are nevertheless exactly as stated.

In conclusion, then, for purposes of greater safety to our present highspeed passenger and freight trains, we urge renewed interest in the matter of adherence to Master Car-Builders' standards in wheel-gauges, track-gauges, and wheel flanges. We also recommend for consideration the changing of the maximum limit between flanges from 4 ft. 5¾ in. to that first adopted in 1886—viz., 4 ft. 5½ in., and further, that a maximum limit for thickness of wheel flanges be adopted. By far the most effectual way of bringing about uniformity and safety, however, would be to have a uniform track-gauge. It is very unfortunate that this country should have two standards—4 ft. 9 in. and 4 ft. 8½ in. So long as this exists, and cars adapted to the narrower gauge are allowed to run over the wider gauge and *vice versa*, each line in fixing its standards must consider the dual conditions that are sure to arise. The subject of uniform track gauge would seem to be one well worthy of consideration by the American Railway Association, which has already done much effectual work in the way of bringing about uniformity in matters which necessarily can only be made effective by action of the managers of our different railroads.

RESISTANCE OF METALS TO SHEAR.

By H. V. Loss, M.E.

The common theory of strength of materials teaches us the action of metals under stress with a fair degree of satisfaction, when exposed to torsional, bending or even most compressive forces. If, however, the engineer or student is called upon to solve a problem where a shearing action is the main element to be considered, he will in vain hunt through text-books or experimental records for light. To be sure, a few scattered experiments have been made, but the writer is not aware of any complete and accurate data pertaining to this subject. The theoretical analysis covering this field is also highly unsatisfactory, there being no formula which the author of this investigation has ever found to be correct and applicable to such problems that will occur—as, for example, in the construction of shearing machinery.

Where a piece of material is to be severed by the action of a pair of knives, no shear will exist in practice without a combined bending action, as the knife blades will imbed themselves quite considerably into the metal before rupture occurs, thus causing a displacement of the center of pressure away from the shearing edge, which displacement then represents leverage.

The clearance angle of the shear-blade—that is, the inclination of the back of the blades upward and downward from the bar—will have some effect upon the amount of power necessary to a certain cut. This effect is mainly, if not solely, felt with new and sharp blades and on light work. For practical machine construction, where we will have to deal with dulled blades and heavy work, this feature can practically be omitted. The knives will in such cases imbed themselves considerably, regardless of the value of this angle; and the experiments did not indicate that the maximum pressures were depending upon the amount of this clearance. It is proper to remark, in this connection, that the standard practice, as based upon experience, when cutting hot material, calls for no clearance angle whatever, both blades being square to the sides. The cold-shearing experiments, treated in the following pages, were mostly made with knives, the clearance angle of which were 1 in 6.

It has often fallen to the writer's lot to have had to undertake the computation and design of heavy shearing machinery. The repeated vexations due to being forced to fall back upon either guesswork or records of former shears—mostly without knowing whether these former shears *safely could* perform such work—led to the inauguration of a series of experiments with the view of finding a guide for engineers in their professional duties. The word "guesswork" is used with due consideration, as the process of taking the number of square inches to be cut, multiplying this number by a certain percentage of the tensile strength of the material, and then regard this resulting product as the necessary shearing power—this process, the writer maintains, is but very little superior to guesswork.

If a beveled knife were to be used, the same rudimentary method would then call for a certain amount to be deducted from the above-mentioned product, the amount of this deduction varying directly with the tangent to the angle of inclination.

It has for a long time been surmised by the writer that the power to sever a bar would not, in all instances, vary directly with its thickness; nor could the power vary directly or indirectly with any trigonometrical function of the angle, representing the bevel of the knife—the angle crossways to the bar. A consideration of extreme values of this angle will readily prove this hypothesis. With a beveled knife there is also, as a matter of course, a limiting value of the width of the bar, that requires a maximum exertion. Above this value the exertion remains constant.

It has been asserted by a large number of engineers that a bar is severed when the knives have penetrated through one-third of its thickness. This is an assertion, however, that needs verification.

The following questions may properly be asked, as being of special interest to the engineer and student:

1. What is the maximum pressure necessary to sever a bar of given dimensions with knives of known bevel?
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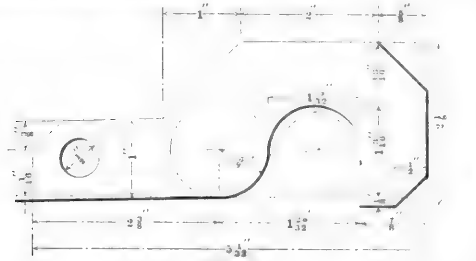

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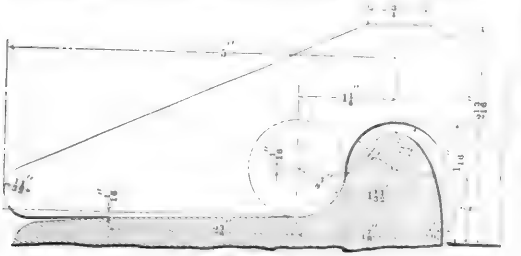

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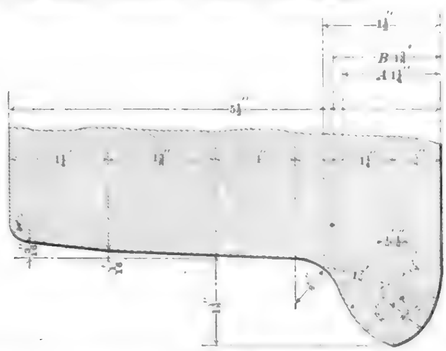

Fig. 7.

Distance between flanges	4′—5½″
Width of one flange	1¼″
Width of one flange	1¼″
Distance over flanges	4′—8″

The above allows ½ in. play on a 4 ft. 8½ in. track. With the 1⅜ in. flange we would have:

Distance between flanges	4′—5½″
Width of one flange	1⅜″
Width of one flange	1⅜″
Distance over flanges	4′—8¼″

Only allowing ¼ in. side play on a 4 ft. 8½ in. track or ⅛ in. on a side. If, however, one chooses to call the thickness of the flange 1½ in. in place of 1⅜, it is apparent that there would be no side play at all on a 4 ft. 8½ in. track.

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Width of flange	1⅜″	
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Wing of frog and frog point	1¾″	
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Difference		⅛″

The flange, therefore, would not clear the frog points by ⅛ of an inch or ¼ in., if the flange in question is rated as measuring 1½ in. Suppose, however, that no exception is taken to thick flanges, and that we attempt to mount them to the standard over flanges:

Standard distance between flanges	4′ —5⅜″
Standard thickness of flange	1⅛″
Standard thickness of flange	1⅛″
Present standard over flanges	4′—7⅝″
Width of thick flange	1⅜″
Width of thick flange	1⅜″
Necessitating a change in standard between flanges to	4′—5⅛″
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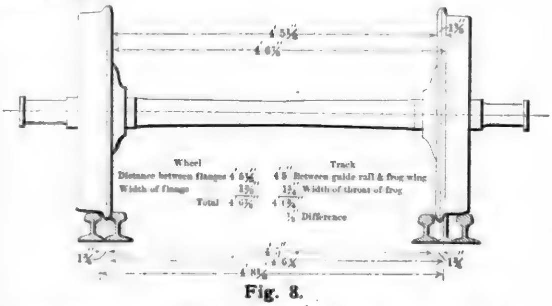

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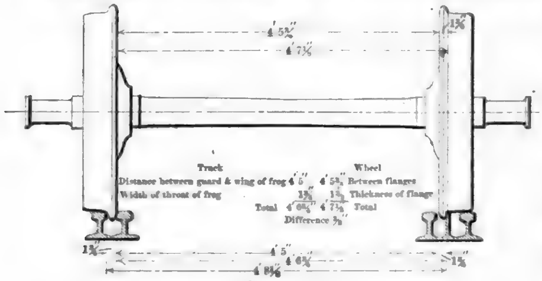

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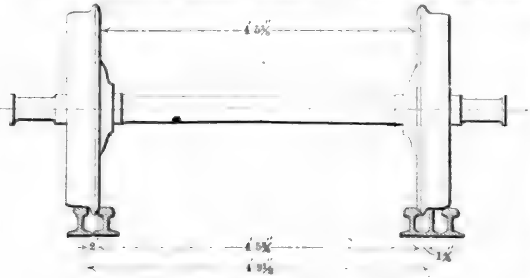

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1. What is the maximum pressure necessary to sever a bar of given dimensions with knives of known bevel?

2. How does the variation in maximum pressure follow the variation in bevel of knives?

3. When is the maximum resistance reached?
4. How does the resistance vary throughout the cut?
5. What is the energy consumed in severing a bar?
6. What is the difference between iron and steel—generally soft—as to maximum pressure and energy?

The questions of pressure required and energy consumed are, of course, the most vital ones for the practical engineer, but any side-light that may incidentally be thrown on the subject lends additional knowledge to a question hitherto rather meagerly treated.

The above numbered questions refer in a general way only to cold materials, but the resistance of hot steel to shear has lately become quite an important consideration, in view of the large dimensions of ingots and blooms, that are necessitated by the present demand in the market for heavy rails and structural shapes.

The construction of hot shears is now a very important branch of mill engineering, and engineers versed in this branch of our profession are aware of the existing diverging opinions in regard to the shearing resistance of hot rolled materials. The writer therefore included in the programme a limited series of experiments on hot work with the view of finding some reliable data. The results are included in the following pages. The most direct manner, involving the fewest factors of uncertainty, in which experiments on shear can be conducted, is by a hydraulic press. A hydraulic differential machine was so constructed as to reduce the high pressures existing in the shear cylinder down to such a figure that would permit it to engage with a common steam indicator. By attaching this differential machine to the press, the motion of its piston would produce a complete diagram showing the pressures existing at any time during the cut.

COLD MATERIALS.

The shapes of heavy dimensions, mostly considered when designing shearing machinery, are bars of rectangular cross-section and angles. Beams are generally sawed off, while thin plates, as for boiler or tank purposes, require, comparatively speaking, a very small exertion. The above-named shapes may occur either in steel or iron.

The iron in the experiments possessed an ultimate tensile strength of about 50,000 lbs. per square inch. The bar steel had an ultimate of 70,000 to 75,000 lbs per square inch, while the steel used in the angles run somewhat higher, or from 75,000 to 80,000 lbs. per square inch, all of which figures represent small specimen tests—that is, from standard test pieces 8 in. long and with an area of ½ sq. in. The carbon in the steel ranged anywhere from 0.16 to 0.22 per cent.

1. Rectangular Cross-sections.

a. Ultimate Pressures.

The appending plates from 1 to 5, both inclusive, show the compiled results on 4-in., 5-in., 6-in., 7 in., and 8-in. bars, with thicknesses varying from ½ in. to 2¼ in. Each plate also contains indicator cards showing the different types, as representing the different bevels of knives. When speaking of a beveled knife it means a beveled top knife only the bottom knife always being square. It may be of interest to know that the bar, upon being met by the knife, invariably turns around its edge, exactly bisecting the angle between top and bottom knives. This is illustrated by the accompanying sketch, fig. 1.

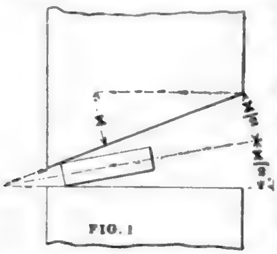


FIG. 1

Repeated measurements proved the accuracy of the above assertion. The angles of top knife used were 8°, 4°, and 0°, or a flat knife. The results, as plotted down, represent generally an average figure or value from a number of experiments on each dimension.

Plate No. 1 shows 4-in. bars with thicknesses from ½ in. to 2 in. Occasionally a continuous average curve has been drawn through the more or less irregular lines which connect the points, as found by experiments. This is done on this plate in the case of 4° and 8° bevels. An inspection will reveal the quickened increase in power with the increase in thickness of bar. The flat knife shows a rather irregular line; but one thing is, however, obvious: *there is very much less decrease in power experienced by the first increase of 4° in bevel, as compared to the effect of the last 4°.* This is a result which is observed throughout the entire series of experiments. The indicator cards show, nevertheless, a distinct difference in ultimate power for all different bevels. With 8° the knife penetrates gradually through the bar, even after the maximum resistance has been encountered and overcome. With 4° the maximum resistance occurs at a later period; but very little work is done after this point has been passed. With flat knives the point

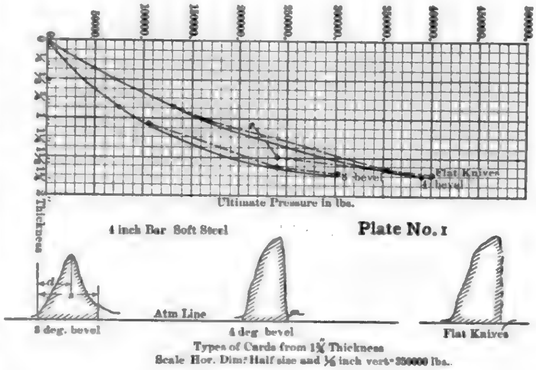


Plate No. 1

of maximum resistance comes still later, but when once reached the bar breaks suddenly, as shown by the vibrations of the pencil, clearly indicated on the card.

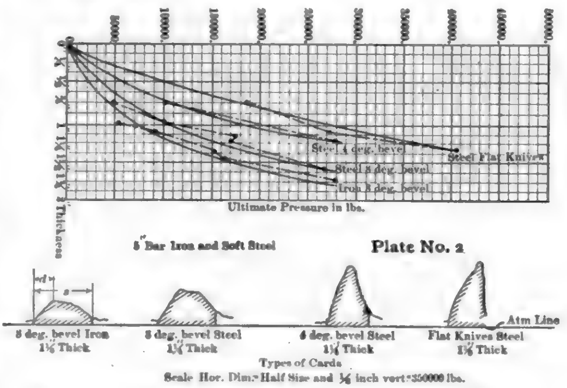


Plate No. 2

Plate No. 2 shows 5-in. bars of steel broken at 8°, 4°, and with flat knives. It also shows iron bars of the same dimensions broken at 8° bevel. Iron and steel at 8° show less differ-

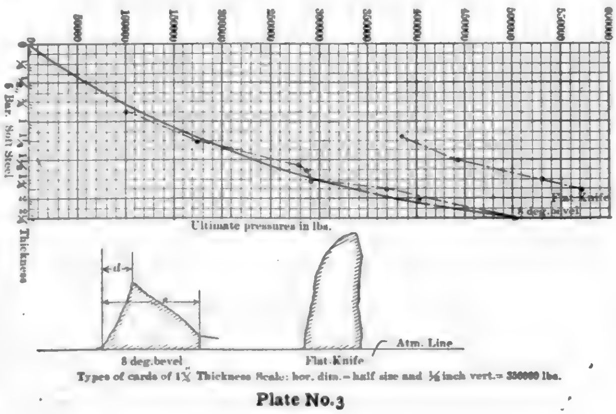
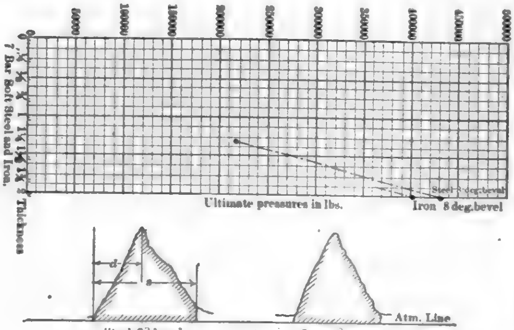


Plate No. 3

ence than steel at 4° and 8°. This peculiarity seemed to exist constantly when iron was introduced into the experiments.

The indicator cards show the same typical forms as existing with the 4 in. bars. With iron the work seems fairly well distributed throughout the stroke, although this distribution is not as uniform, however, with an increasing thickness.

Plate No. 3 shows a very complete line for a 6-in. bar with



Types of Cards from 2 Thickness
Scale: Hor. Dim.= half size and ½ inch vert. 350000 lbs.

Plate No.4

an 8° knife up to 2¼ in. in thickness. The flat top knife shows also very distinct and positive results. The quickened increase in power with increase in thickness is again here, as everywhere else, clearly indicated.

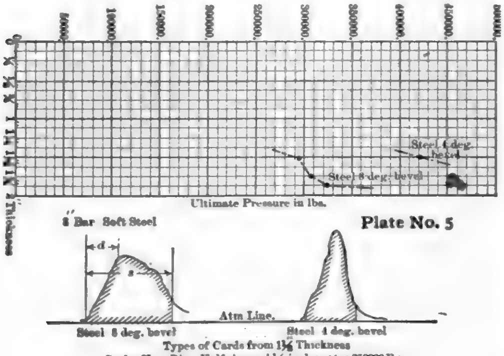


Plate No. 5

Types of Cards from 1¾ Thickness
Scale: Hor. Dim.=Half size and ½ inch vert.= 350000 lbs.

The indicator cards emphasize the different distribution of work, due to different angles of knife. The sudden break with flat knives, after the maximum resistance has been reached, is once more demonstrated.

Card showing the effect of width upon ultim. pressure.
Bevel of Knife 8 deg.

Plate No. 6

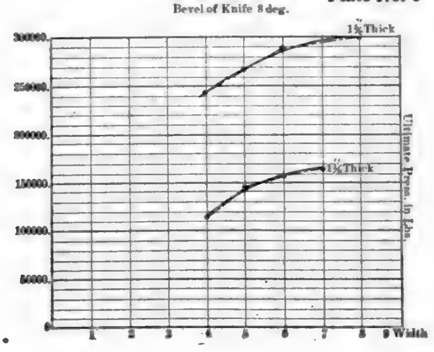


Plate No. 4 on 7-in. bars shows, again, the before-mentioned fact, that iron and steel do not give very different results at 8° bevel of knife.

The forms of the indicator cards are also very similar, both as to pressure and distribution of work.

Plate No. 5 shows some results on 8-in. steel bars with 8° and 4° knives. The results do not combat any of the previously mentioned characteristics.

All the experiments so far seem to indicate that *with large bevels, iron and steel vary in ultimate shearing resistance, apparently in a smaller ratio than the one existing between their tensile strengths.* They also seem to demonstrate that *to cause a telling decrease in shearing power the angle between knives ought to be more than* 4°, as an increase in bevel above this figure decreases the shearing power very rapidly.

Plate No. 6 shows the decreasing effect of the width of a bar upon the ultimate power whenever a beveled knife is used. *With 8° it seems to indicate that anything above 8 in. in width, when about 1½ in. in thickness, requires no additional power. With 1¼ in. thickness the limit seems to be reached at 7 in. in width.* The thickness seems, therefore, to effect the limit to a certain extent, everything else remaining constant, as a difference in thickness of ¼ in. results in a decrease or increase in the limiting value of width of 1 in. This seems upon reflection to be quite natural. The less thickness of bar the less becomes the absolute penetration of knife, as also the amount of width engaged by the inclined blade or *vice versa* before rupture occurs.

Card showing
The Relation between Pressures
due to different bevels of knife and different
thicknesses of bars.
Soft Steel
Vertical dimensions indicate pressures

Plate No.7

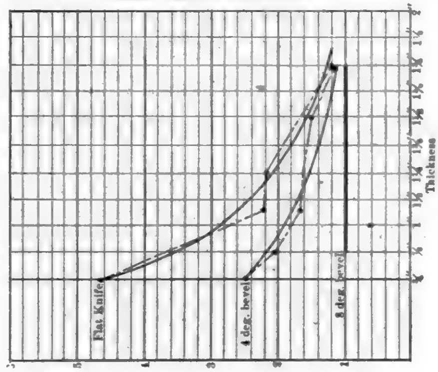


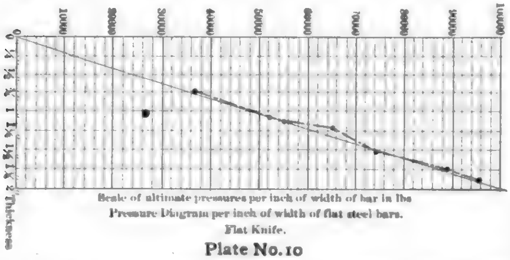
Plate No. 7 shows one important fact. *With increasing thickness the effect of any bevel, however steep, disappears quickly.* At 1¾ in. thickness there is only a difference in shearing power of 19 per cent with 8° difference in bevel, while this very same difference in bevel with ¾ in. thickness causes a difference in shearing power of 360 per cent. This extraordinary difference is mainly, if not solely, due to the fact that with large thicknesses the bar has to be broken instead of sheared. Under such conditions the knives do not penetrate very deeply, comparatively speaking, before rupture occurs, and the effect of the bevel is greatly diminished. At about 2 in. or 2¼ in. in thickness, it would appear that all difference would be eliminated. The following table gives the figures from which the diagram has been constructed. The necessary shearing force with 8° knife has been considered as a basis.

TABLE NO. 1.

Thickness of Bars.	Relation between Pressures with Bevels of Top Knife of		
	8 Degrees.	4 Degrees.	Flat.
¾"	1	2.5	4.6
⅞"	1	2.05	...
1⅛"	1	1.66	2.00
1¼"	1	1.63	1.97
1½"	1	1.54	....
1¾"	1	1.16	1.19

Plate No. 10 shows a very decided result as to the effect of thickness upon ultimate pressure when using flat knives. The vertical dimensions represent ultimate pressures *per inch of width* of steel bar, each separate result being the average value as taken from all widths of bars having any one thickness. The close coincidence between the broken lines and the full line directed toward the zero mark is very apparent. It means *that the ultimate shearing resistance of a flat bar is in direct proportion to its thickness.* This result is foreshadowed on some of the pressure plates, especially on No. 2. In this one instance the old rudimentary method of determining the ultimate resistance seems to approach the truth.

In finishing the remarks on the ultimate resistance of rectangular bars, it is well to call attention to the small resistance per square inch of section that exists with a beveled knife when cutting thin bars. A 6 × ¼-in. steel bar requires only 19,000 lbs. per square inch of section with an 8° knife, while



Scale of ultimate pressures per inch of width of bar in lbs
Pressure Diagram per inch of width of flat steel bars.
Flat Knife.

Plate No. 10

a 6 × 2¼ in. bar requires 40,000 lbs. per square inch for the same bevel. As the knives become flatter, however, this difference decreases very rapidly. Under these conditions I have, therefore, entirely abandoned the term *resistance per square inch* in connection with the shearing of cold materials, and simply considered the total ultimate resistance. Indeed, when remembering the different complex strains which exist when shearing a bar, especially with a beveled knife, it is almost absurd to use such a term, when expecting all square inches of the bar to do equal duty. We might as well be justified to inaugurate a "bending resistance per square inch," which, when multiplied by the number of square inches in the cross-section of any beam would represent its resistance against flexure.

(TO BE CONTINUED.)

DISCREPANCY IN CHEMICAL WORK.*

By C. B. Dudley, Chemist Pennsylvania Railroad Company, Altoona, Pa.

My theme is: "Discrepancy in Chemical Work by Different Workers." What are the causes of discrepancy in results obtained by different chemists?

I have recently seen a series of, probably, 16 determinations of sulphur in a piece of pig iron, supposed to be the same iron; that differed from each other from 0.005 up to 0.02 per cent., or the extreme results (these figures are given from memory) were about as 1 to 4. Now, obviously, while the amount of sulphur is excessively small in this case, not being a matter of very great importance, yet, as bearing on the accuracy of chemical work, the result is something appalling. I have seen a series of phosphorus determinations recently, made by six or seven chemists, where the extreme results differed 0.03 to 0.04 per cent. in a total of about 0.10 per cent. A friend of mine, who, for a number of years, was manager of a large furnace, some four or five years ago sent out borings from some pig iron to eight or nine different chemists for phosphorus determination—this is another case besides the one just referred to—and when he got the results back, no one of the chemists knowing that any other was working on them, they differed almost as 1 to 2; and, in his nervous, energetic way, he said: "'I said, in my wrath, all chemists are liars!'" Perhaps it is not necessary to mention any more discrepancies; but one more instance may be given. In a recent analysis of bronze, we obtained, in our laboratory, a trifle over 9 per cent. of tin; another chemist, working on what was supposed to be exactly the same metal, being half of the same pig, got over 10 per cent., the discrepancy being about 1¼ per cent. Now, obviously, there is something wrong somewhere. Why is it that we get such discrepancies? Undoubtedly, most of you have reasons quite ready to explain some, at least, of the discrepancies. I have gone over the subject recently, and think the causes for discrepancy in chemical analyses may be grouped under four heads. You can say, after I am through, whether there are more; whether the ground has been covered; whether something has been left out, or whether too much has been included.

The first cause of discrepancy in chemical work is that the two chemists did not work on the same sample; or, in other words, non-uniformity of samples. Upon this point, your own experience will doubtless give each of you an illustration. I do not have in mind now anything occurring out of our own personal experience in our laboratory work at Altoona, now nearly 17 years of it, where there has been serious discrepancy due to difference in sample. The nearest we have come to it is this: At one time we were buying spiral springs on specifications that the carbon should not be below .90 per cent. The springs we examined were made out of a steel wire about a quarter of an inch in diameter, the coil being about an inch and a half across, and five or six inches long, what we call "A" springs, and used to hold the box lids tight to the oil boxes under the cars. We found in those springs so low carbon, in a number of cases, that we rejected them. The manufacturer got some one else to determine the carbon in the steel, and found the requisite amount; and so, of course, the question came up for an explanation as to the discrepancy. The discrepancy was very easily explained, and we ourselves, in our later work, found the same peculiarity in other steels; the borings required for analysis of these springs (they were unhandy, unwieldy things to bore, being small) were simply what we could get handily, mostly from the outside of the wire. The manufacturer took the same springs, had the outside turned off, and then took his sample from the center of the wire, and this was the cause of the discrepancy, as we have proved by a number of test analyses. Apparently the outer layer of a steel rod that has been heated, as is commonly done with spiral springs, very frequently loses .10 per cent. of carbon in the fire. Or it may be, segregation during cooling explains the difficulty. At any rate, we have several times done this—viz., take a wire rod ⅜ in. in diameter, and have the boring done from the side, not the end, with a ⅛-in. drill, may be $\frac{3}{16}$ in. deep, and then make a carbon determination from these borings, and then take $\frac{3}{16}$ in. more toward the center and make a second carbon determination; we never get the same carbon in the two samples. This is the nearest to an easy illustration that I can give you of discrepancy due to difference in sample Of course, it is perfectly obvious that if the samples differ, there is a legitimate and good reason why the analyses should differ. This is especially true of shipments that are made up of large quantities, and are sampled by the single sample. We have many times had this brought to our attention by the men at the shops. Samples taken out of the same lot of material may not show up the same. They say it is the same material because it came in the same car. This is especially true in oil samples It is not at all rare for a manufacturer who receives an order for 50 barrels of lard oil, for example, not to take that oil all out of the same tank, although he ships the 50 barrels in the same car. We have had a number of cases where the amount in tank did not suffice to fill the order, and, consequently, some was taken out of another tank, and sometimes inferior material was put in—two or three barrels, as the case might be—to fill the order. But it is not necessary to go further upon this point. You will all recognize that there is a clear and sharp reason for discrepancy in analyses if the samples are not the same; and in all our work, when we come to a serious difference between ourselves and any one else, we exchange samples. That is one of the first things we do—exchange samples to see whether the difference lies there.

The second cause for discrepancy in chemical analysis is impurity in the chemicals. Many of you have doubtless run across this peculiarity. One of the most recent we ran across was this: In mixing up some wash water of sulphate of ammonium and free sulphuric acid for washing the yellow precipitate in phosphorus determinations, we ran across a very puzzling sort of trouble—namely, after washing a few minutes the filtrate became turbid, and the more we washed the more turbid it became, and we were inclined to think that the published statements of the insolubility of the yellow precipitate in sulphate of ammonium and sulphuric acid wash water were probably fallacious; but on looking into the matter we found that the commercial sulphate of ammonium we had used had a little phosphorus in it.

There are many discrepancies in analyses due to the impu-

* An address before the members of the Chemical Section of the Engineers' Society of Western Pennsylvania at Pittsburgh, September 27, 1892.

rity of the chemicals used, and it is not always an easy matter to say whether the chemicals are pure or not. It may frankly be said to you that the longer I work, and the more experience I get, the more I am inclined not to be so sure as I used to be. Obviously, there are two or three methods of checking up whether the chemicals are pure or not. One of the most common is simply to test the chemicals; but it is not clear how anybody would have found the impurity by that method, which was run across in the work of the International Committee on Standards in carbon determinations—namely, the presence in chloride of ammonium of a little organic matter, that only comes out when you dissolve steel in the double chloride of copper and ammonium. Another method is to make a dummy analysis, using a second beaker, to which you add only the reagents that you use in the one containing the substance to be analyzed, and then weigh up what you get from the two, and deduct from the genuine analysis what you find in the dummy. There is always a little uncertainty in that—namely, have the same reactions taken place in the beaker that has not got the substance in to be analyzed that have taken place in the beaker that has the substance? There is one thing more present in the beaker that has the substance in, and this additional thing may introduce changes in the final result. The dummy analysis is not always quite certain; in many cases it undoubtedly is. You may not always catch up the impurities of the chemicals by the dummy analysis, nor would I think that you could always catch up the impurities of the chemicals by a test, as it is so difficult sometimes to test them.

This is a thing that all of us, undoubtedly, need to pay a great deal of attention to. Your attention may be called to an instance. We had some so-called C. P. molybdic acid from five different sources recently; three of them had ammonia present; one of them was free from ammonia, but there was a little soda or some other soluble base with it; and one of them was pure molybdic acid, as far as we could get at it. Such peculiarities as these many times may possibly cause discrepancy. It is evident that in making up a solution of molybdate of ammonia, if you have something called molybdic acid, and put in the amount required of this material, and it is in reality molybdate of ammonia or of soda, you do not get the same strength of solution you would have if genuine molybdic acid had been used. Our experience indicates that this point cannot be ignored in phosphorus determinations. Your own experience will, of course, do two things for you: first, warn you (has already warned you undoubtedly) never to trust results of analysis unless you have checked up the chemicals, and, second, will convince you that there are many impurities in so-called C. P. chemicals.

A third cause of discrepancy in chemical analyses is what may generally be called "poor manipulation." There are chemists who think this is the principal cause. The main cause of discrepancy in chemical analyses, some say, is poor manipulation, or lack of skill. My old teacher in chemistry, who has now gone out of the business, and lives on a farm in California, was characterized by this one very remarkable peculiarity—namely, he never believed anything as long as there was a shadow of doubt, and after all known uncertainty had been removed he was not quite sure; in other words, he was a man who was really a struggler for accuracy. He used to say to me in his very dry way: "No chemist can make an accurate analysis. There are chemists who can work near enough to accuracy so that their work is valuable. There are chemists who cannot. And that is the difference between chemists." Of course, what I mean by an accurate analysis is a question of limits. Some analyses are accurate to a half per cent., some to a tenth of a per cent., and some, perhaps, to a hundredth of a per cent., but probably none are the exact truth.

The point I want to make, however, is not a dissertation on accuracy, but the difference between chemists due to manipulation. Undoubtedly, this is a very frequent source of error. I remember very well when I was a student, I was set to make a determination of iron. I dissolved the substance in sulphuric acid with the utmost care, excluding the air, and, at the end of the operation, after going through the necessary routine, I filled up my flask to one litre, shook, and supposed I had a solution that was in every sense what it should be for the subsequent operations, which were to draw out successive portions of 100 cub. cm., and titrate them with permanganate of potash. To my surprise, the first two that came out differed from each other from 10 to 15 per cent. What was the difficulty? Why, simply, I had not mixed the materials. I thought, in my inexperience, that if they went into the same flask, it was all right if I gave it a shake and a stir. Let me give you another illustration. Recently, we had occasion, in our laboratory, to make some tests for phosphorus, and I set two or three boys at the same thing. We knew pretty well from good careful manipulation and fairly well-tested methods what the steel contained, and the directions were to wash the yellow precipitate until the wash water tested with sulphide of ammonia showed no change of color. We were washing out molybdic acid and iron salts, and, as you know, both the molybdic acid and the iron would show change of color with sulphide of ammonium. In some five determinations, one of the boys got (it was low steel, containing almost exactly 0.4 per cent. of phosphorus) .048, .047, .051, .043, .045. You will note the discrepancy, and yet he had followed the directions, as he supposed, with absolute accuracy.

There are two points involved in this illustration—namely, to show how the manipulation may be at fault, and, also, however accurate you may be in giving directions as to how analyses shall be conducted, you may be thwarted by something you had not thought of. Well, on careful examination, we located the difficulty. The difficulty was simply this: the yellow precipitate had a little tendency to crawl, and this manipulator was a little bit afraid it would get over the top of the filter, and, possibly, get carried down through with the washings, and in his anxiety to avoid this he failed to wash all the molybdic acid out of the upper part of the filter. He supposed he was washing it out completely, but as the result showed by failing to wash to the top of the filter he removed so little with each successive addition of wash water that the amount was too small to react with sulphide of ammonium, so that, although he accurately followed the directions, he still left enough molybdic acid (which you know, by the volumetric method, is what we are really measuring) in the filter to give a little high results.

Hundreds of illustrations will, no doubt, occur to you where manipulation comes in as an element of error. Directions are given, say, for example, to heat to a certain temperature. One man guesses at it; another puts in a thermometer. Again, the directions may be very indefinite. They may be, for example, "add a little of this or that," or "add a little, not too much," without giving any measurements whatever. Or the directions may be accurate—"add 5 c.c.," or "10 c.c."—and one man guesses at it, and another measures it. The manipulation certainly does affect the analysis. In filtering, one man slops a little, and another does not. All of these are points that come in, so that I think, without further question, you will accept this as one of the reasons why there are discrepancies in analyses—namely, failure on the part of one or the other of the chemists in accuracy of manipulation.

Now there is a fourth cause for discrepancy in analyses, if I understand it rightly, and that is the method. I think you will all agree that two methods may not give exactly the same results. I have in mind a couple of cases which occurred quite recently with us. In a determination of tin in bronze, we never weigh up the metastannic acid as we separate it from the bronze by means of nitric acid. We have never succeeded yet in getting all the iron and all the copper away from the oxide of tin by means of nitric acid. Also if the bronze contains any phosphorus, it will, as you know (part of it, at least), go down with the tin. Even if you take an ordinary straight bronze that is simply a copper-tin alloy, and dissolve it in nitric acid, and weigh the tin just as you get it by separation in nitric acid solution, we think your results will be a little high. So we dissolve our metastannic acid in sulphide of ammonium, filter and reprecipitate the tin sulphide; in this way we always get a little copper out, and sometimes a little iron. And although, as you know, we do not even with this care completely separate the copper from the tin, owing to the solubility of copper sulphide in sulphide of ammonium, we think we get much nearer the truth than if we neglected this precaution. On the other hand, I have known cases where it is quite the custom to weigh up the metastannic acid just as it is separated from the other constituents of the alloy by means of nitric acid. Now here is difference of method. No one would think those two methods ought to give the same results.

I have another illustration: We have been accustomed for a little while to determine the lead in alloys by precipitating lead on one of the poles of a battery as binoxide, according to Edward Smith's recent manual of electro-chemical analysis, a book which, by the way, each and every one of you ought to have and study carefully. I need not give you the detail of the method further than to say, that if you have copper and lead in nitric acid solution and apply the battery, the conditions being all right, the copper precipitates on one pole as metallic copper, and the lead on the other as binoxide. If we may trust our experience the results are excellent, if you have nothing else but copper and lead present. We took a known amount of lead and put in with it a known amount of copper, and get out almost the actual amount we put in, so that we think the method is capable of great accuracy. But in a re-

cent analysis of a bronze containing lead we got 1 per cent. higher in lead than somebody else got by the sulphuric acid method, and the worst of it was that when we came to determine the lead by the sulphuric acid method, we confirmed the other chemists' results. It took a little time to find out where the difficulty was. I may say, for your information, that bismuth follows the lead, if it is in small amount; if it is in large amount, it will go with both the copper and the lead. We found a trace of iron in with the lead, and just the faintest trace of copper, a little tin, a trace of antimony, and strong suspicions, but not positive proof, of bismuth, apparently enough, in the aggregate, to account for the discrepancy. So we see that all methods of procedure are not equally good. All methods will not give the same results. "Method," therefore, is a fourth cause of the discrepancies in chemical analyses.

I would like to spend just a moment on another thought that comes in perhaps under manipulation best, but almost seems worthy of a place by itself—namely, there is frequent discrepancy, if we may trust our experience in chemical analysis, due to the fact that one chemist knows what he is doing, and the other chemist simply follows directions and doesn't know what he is doing. I have seen a good many chemists make chemical analyses whose minds seemed to be anywhere else except upon the analysis; whose minds did not follow the changes that were taking place; who did not understand the rationale of the process. I have seen other chemists whose minds were always engaged upon the changes that were taking place while they were making the analysis, even during the filtration. One thinks, "What are we washing out?" The other thinks only, "The book says, wash," and so he goes ahead and washes. He doesn't think what he is washing out, and usually doesn't test to see whether he has washed it all or not, unless, perchance, the book especially says so; he is thinking of something else. We had an illustration of this lack of thinking what is going on in the progress of an analysis which caused us a little annoyance recently. This very puzzling thing happened to us: We made an analysis of a tire and found about .14 per cent. of silicon in it. The analysis was made by the Drown method, dissolving in sulphuric and nitric acid evaporating until the sulphuric acid fumes, and then diluting with hot water and filter. You are doubtless all familiar with the manipulation. As I said, we found .14 per cent. of silicon in this tire. About a month after it was sent out we received a letter from a chemist of another railroad, saying that he had seen the analysis that we made of the tire, and that his determination of the silicon in the same tire was nearly double ours, and asked us to kindly send him our method, so that he could check himself up and see where he was wrong. He was very nice about it, you see. Before sending him the method, we though we would go over our own work again, and upon doing so, confirmed his results. I would like to say here, in parenthesis, that the average of our work does not cause us this trouble. We make a great many hundreds of analyses, and these are only a few cases, but they happen to illustrate my remarks, and it is better that I should draw my illustrations from my own experience, if possible. Where was the difficulty? Our subsequent work, I say, confirmed the analysis of the other chemist; we got .28 per cent., same as he did. On looking the matter over we found the difficulty. A great deal of work is done in the Pennsylvania Railroad Laboratory, and much of our work is the examination of shipments of commercial products that are bought for use on the road. Now, other people's actions depend on the results of our work. If, for example, we buy a shipment of 100 barrels of oil, none of that oil can be used, unless some very great emergency has arisen, until the laboratory report is furnished to the parties who are to use it, so that we must not allow anything, unless it is very serious, to interfere with our doing that work. It happens, therefore, that the work on shipments takes precedence, and the investigation of miscellaneous samples takes our leisure time when we are not working on shipments. This was the case with the tire. The operator who had the matter in charge, apparently without thinking exactly what he was doing, since he was doing a great deal of other work, and had many irons in the fire, dissolved the steel in the regular way, evaporated to the fuming point (just as he should have done), but, then, instead of diluting with hot water and filtering at once, he diluted and let it stand. It happened it stood 48 hours. Now, it is possible that none of us would have thought that this would cause any trouble, but subsequent experiment showed that this was the explanation of the discrepancy. Apparently, the silicon obtained by the sulphuric acid method is not dehydrated completely. At any rate, we made positive determinations subsequently on the self-same tire, and if we allowed it to stand 48 hours after dilution, we lost about half of it. If we allowed it to stand six days we only got .06 per cent. I said to our boys that I was glad the thing had happened, because it brought out a point we would not have thought of easily otherwise. Nevertheless, it seems to me that a chemist who thinks much, and who carries his work with him, and understands what is going on, would have thought that possibly there might be danger in the delay.

Now, we come to perhaps the most important point in our whole talk—viz., How shall two chemists who differ check each other up? or, come to an agreement with each other? I answer, Where two chemists differ, and the difference is due to working on non-uniform samples, or on not exactly the same sample, the matter is easily checked up by changing samples. Also, differences due to impurity of the chemicals are not very difficult to check up, either by checking up your chemicals, or by the dummy. Sometimes, it is true, the differences due to impurities may be very abstruse and hidden and difficult to find; but by changing chemicals, as we have done a number of times, you can frequently locate the difficulty. Also, still further, where manipulation is at fault, it is not a very difficult thing for the two manipulators to get together and work in the presence of each other, as is frequently done, I understand, in Colorado in assaying. One of my assistants is an old assayer from Colorado, and tells me that, many a time, he and the works' chemist or assayer have worked in the same muffle, side by side, and under the same conditions, so that each could watch the other. Many times it is not necessary to go as far as this; simply talking over the manipulation will show wherein the difficulty lies. These three difficulties—or, rather, discrepancies due to these three causes—are not very hard to overcome; but here comes the poser. Suppose that the difference is due to method, and suppose that I say I have used a good method, an approved method, a published method that is recommended, and you say the same in regard to your method, who is going to decide between us? Both of us are, perhaps, a little obstinate, and both of us perfectly right in the position we have taken. If both of us have used regular, well-recommended methods, who is going to decide between us?

Before answering, let us see what is the necessity for a decision. Oftentimes a good many thousand dollars depends on our work. If we make a mistake by using a bad method or a wrong method, it may mean a good many thousand dollars to somebody whose product we have rejected. He may have to pay the return freight and have the product sent back on his hands; and, as it doesn't pass specifications, he may not be able, without serious loss, to sell it. On the other hand, if the chemist, on the other side, has used a bad method, we may have to accept inferior material. As you know, more and more every day, large commercial transactions are based on chemical analyses, and differences between chemists may mean thousands of dollars.

We have proposed the following method for overcoming this difficulty. I do not know that it will be approved by the profession, but we do not see any other way out of it, and many chemists and managing men of the different mills whom we have consulted on the matter have approved the suggestions we have made. The method is simply this: Publish the method we use, and make it a part of the specifications. For example, suppose we are buying spring steel on specifications that it shall not contain over .05 per cent. phosphorus. Now, we will suppose that I use the volumetric method, another man uses the acetate method, and we get different results, who is going to decide between us? We have either got to leave it to some third party, and agree to abide by his decision, or have the same method. Now everybody knows that it is impossible to run a large commercial laboratory on the acetate method for determining phosphorus; it is too slow; and, also, on the other hand, it is claimed that the volumetric method is not quite so accurate as the acetate method. Perhaps I shall have something to say about that some other time. But what are we going to do? We simply say this to the manufacturer: "We want steel for springs that shall not contain over .05 per cent. of phosphorus, and the phosphorus shall be determined in a given way. Whatever you find by this method, that is the amount of phosphorus so far as our transaction goes." We see no other way out of this difficulty. Now let us see; this is a pretty bold assumption; the chemist of the Pennsylvania Railroad Company assumes to dictate to the profession what methods they shall use. Yes; but only for transactions in which the Pennsylvania Railroad is involved. Use any method you choose for your own work; we do not assume to dictate to you a particle; but as a means of avoiding the difficulty due to difference of method, we simply say to you, arbitrarily, that this is the method that must be used to determine the phosphorus, for example, in transactions where the Pennsylvania Railroad is involved. If we had a standard method, or if any learned society will give a method

which shall be regarded and accepted by chemists as final, we will bow to it instantly; we will adopt anybody's method, if it is applicable. We claim no especial originality; we simply give you the method which we use.

Now let us see what is going to come of this. We prescribe a method which shall be used for determining phosphorus, carbon, silicon, sulphur, or whatever it may be. The method as we use it will give certain results; the other chemist will get the same results, at least we assume that he will. The Pennsylvania Railroad Company puts an upper limit on phosphorus; since phosphorus is injurious to steel, that is to say, the phosphorus must not go above so much; the interest of the railroad company is to have a method that gives as high results as possible, so as to keep phosphorus down; the steel works' chemist, on the other hand, desires that the method in his hands shall show that the steel is low in phosphorus, because if it gets above a certain amount it is rejected. In other words, the two parties are on opposite sides of the method. It is one's interest to have a method that will cause the rejection of the steel if it is high in phosphorus, and the other wants a method that will make the steel pass. Now, my experience is that in anything where men's pockets are involved on opposite sides of a question, you are pretty apt to get at the truth sooner or later. This is going to bring a criticism of the method of determining phosphorus by the parties in antagonistic interest. Our thought is this: The method we send out to-day is entirely subject to revision; if any one of you finds a hole it in, say so, and the change shall be made just as soon as we can make it, providing your work is confirmed. It is not our method; it is a method to be used to decide certain chemical questions. Our hope is that there will be enough criticism by these parties in antagonistic interest on the various methods put forth, so that sooner or later there will result a method which we will all be willing to accept as standard. It may be that the work of 50 chemists will be required before we get such a method. There is no assumption on our part of superior knowledge; no désire to dictate in any shape or form to the profession; but we have a difficulty to meet, and we cannot see how to get out of it in any other way.

I asked Professor Langley what he thought of it. He said he thought that some learned society should approve the method. Per contra, a member of the American Chemical Society is reported to have said that he would bitterly oppose any attempt on the part of that Society to sanction any method. He did not think any learned body should sanction a method. On the other hand, the agricultural chemists of this country, as I understand it, have done this very thing—namely, they have agreed that in the analysis of fertilizers whatever phosphoric acid is shown by a certain method, which they defined in convention, shall be called "soluble" phosphoric acid, and the amount of phosphoric acid that is shown by another method or modification shall be called the "reverted" phosphoric acid, while the amount of phosphoric acid shown by still another method or modification shall be called "insoluble" phosphoric acid. The method was first proposed five or six years ago; has been modified three or four times, and now nearly all the agricultural chemists in the United States, if I am right, are determining the phosphoric acid in fertilizers by the method adopted by the agricultural chemists in convention. If some convention would take this work off our shoulders, we would be delighted. We assume it only because we do not know how to get along and meet our difficulties any other way.

I shall be very much obliged, indeed, for any criticisms and suggestions which any of you may have to make on this scheme, and anything you can contribute in any way, shape or form, you will find falls upon very willing ears.

PROCEEDINGS OF SOCIETIES.

Engineers' Club of St Louis.—At a meeting held January 18, Mr. George H. Pegram presented a paper on The Bridge across the Arkansas River at Fort Smith. A full description of the construction of the bridge was given. The piers were built of concrete, using Portland cement.

Iowa Society of Engineers & Surveyors.—At the annual meeting held at Des Moines, January 18 and 19, it was voted that the Society co-operate with the "good roads" movement in the State. The Society asks that the office of County Surveyor be filled by competent engineers, and that the duties of the office be increased by adding oversight of bridges and of the roadwork in general. It also asks for an examining commission to determine the competency of such officials.

Engineers' Club of Minneapolis held their annual meeting on January 12, at which Mr. Charles Steiner, of Zurich, Switzerland, read a paper upon the utilization of Minnehaha Falls for power purposes. He has investigated and made a preliminary estimate, based upon the flow of about 150 cub. ft. per second as a minimum, with an effective fall of 93 ft. giving about 1,600 H.P.; the cost of the improvement he estimated at $135,000. The scheme would spoil the park, but he proposed to beautify the latter in many respects and let the falls run on exhibition a few hours three times a week. By storing the necessary water in the surrounding lakes and using it in dry seasons he proposed to avoid all trouble from lack of water.

Social Reunion of the American Society of Mechanical Engineers.—This Society has resumed its social reunions for 1893. The first one was held on the evening of January 26, and others will occur March 30, April 27, and May 25. There has been some inquiry among members to learn why the monthly meetings for the discussion of technical subjects, which were tried last year, and with marked success, have not been resumed this winter. Some members say, and it seems with great justice, that if a national Society of Mechanical Engineers accomplishes little more than establishing a lodging-house in New York, and holding a kind of church sociable during the winter and free excursions in the summer, that the Society has failed in the purpose for which it has been organized, and if it does little else might as well be disbanded.

Columbian Engineering Congress.—A recent dispatch from Washington to the daily papers says: "Engineer-in-Chief Melville of the Navy is in receipt of several valuable papers which will form a part of the division of marine and naval engineering of the International Engineering Congress of the Columbian Exposition.

"These papers are to be printed by the seven divisions which constitute the congress. The discussion will take place during the first week of August, and in the discussion three languages, besides the English, are permissible—French, German, and Spanish. All of the divisions have secured papers from the recognized authorities on the subjects treated, and the experts of this country and of Europe have prepared articles which will be valuable contributions to science.

"The officers in charge of the seven divisions are, with the exception of Mr. Melville of the Marine and Naval Engineering Division and Professor Baker, of Chicago, of the Engineering Education Division, New York men. The Division of Civil Engineering is in charge of F. Collingwood, the Division of Mechanical Engineering in charge of F. R. Hutton, the Divisions of Mining and Metallurgical Engineering in charge of R. W. Raymond, and the Division of Military Engineering in charge of Major Clifton Comly of Governor's Island, New York Harbor.

New York Railroad Club.—The February meeting of the Club was held at the rooms of the American Society of Mechanical Engineers on the 16th. The topics under discussion were:

1. Should dead blocks be applied to freight cars with M. C. B. couplers?
2. Can a successful draft rigging be applied to freight cars without the use of auxiliary timbers; in other words, fasten draft gear to end and center sills?
3. Which offers the most security for automatic couplers, a tail bolt or a yoke attachment?
4. Is any device using a netting a real "spark arrester"? If there were absolutely no laws on the subject except that roads should pay for damage done by fires caused from locomotives, would any of us use extension fronts or diamond stacks?
5. What are the best proportions for driving-boxes? Is not the present size faulty design, and can it not be remedied easily?

The discussion on the first topic showed that there was a considerable difference of opinion in regard to the desirability of the dead blocks, but in sifting out the evidence it may be said that it resolved itself into preponderance of opinion in favor of the use of dead blocks. It was shown that the Western roads were using cars on which there were no dead blocks, but that when such cars were in collisions they were more badly broken than cars of Eastern lines, which were provided with the dead blocks. The safety of train men seem to require that the dead blocks should be used, although it was stated that there were more accidents caused from the arm or hand being caught between the blocks than occur by men

being crushed between cars that were violently brought together through the failure of the coupler or draft rigging. Mr. West, of the Ontario & Western road, stated that his company now had two suits on their hands for accidents, one because the cars were not equipped with dead blocks, and the other because they were. Evidence of brakemen seem to show that they considered cars equipped with the dead blocks decidedly safer to couple than those without.

The discussion of the second question was of the most desultory character, and nothing of importance was brought out.

Regarding the third topic, there seemed to be an opinion favorable to the use of the tail bolt rather than the yoke. Mr. Smith, of the Union Tank Line, stated that his company had a large number of cars equipped with tail bolts in which there were two keys made of malleable iron, and that they had never had a breakage, but on cars where the bolt was headed trouble was frequently experienced by the head breaking off or pulling through. The Western lines seem to be favoring the yoke. Attention was also called to the fact that the difficulty with the tail bolt might lie in the method of heading them. If the metal is not hot enough to flow readily in the die, and the man who is doing the work is on piece work, there is apt to be a straining of the metal under the head, resulting in a crystallization, which will shortly produce a fracture, and such crystallization is always found where the heads are broken off, a thing commonly occurring on bolts of 2¼ in. in diameter.

Regarding the fourth question, it was answered most decidedly in the negative as far as there being any real spark arrested, but it was agreed that the extension front itself did efficient work; and there is probably no doubt that it has an advantage over the diamond stack in that the exhaust nozzle is above the netting, and the fire is not torn up as much as with the older appliance.

The general sentiment seems to be that the extension front with a brick arch in the fire-box was the most effective of spark arresters. It was stated that many English engines are running without any netting whatever; and Mr. Dixon cited an instance where an engine on the West Shore road that had originally been fitted with an extension front was run for some time, owing to an accident, with an open stack and no netting or diaphragm in the smoke-box. The result of this, however, was that the machine threw the sparks very badly.

Various methods were suggested for increasing the size of driving-boxes lengthwise. One was to hang the springs from underneath, so that they could be brought central, and another was to use a saddle with a wide leg on one side, so that the spring could be drawn more nearly central with the box than is possible when placed centrally over the frame, and the box is lengthened toward the inside of the engine. The matter of materials for the driving-box was incidentally touched upon, and brought out the fact that solid brass boxes or cast steel were considered far preferable to those of cast iron.

Boston Society of Civil Engineers held their regular meeting on Wednesday evening, January 25.

Mr. Edward P. Adams read a paper on the Light-House System of the United States. The paper covered in a very comprehensive manner the history and theory of lighting our coast and the present organization of the system. The paper was illustrated by drawings and photographs of the various forms of light-houses, beacons, buoys, sirens, etc.

American Society of Civil Engineers.—At a meeting of the Society, held on February 1, a paper was read by Robert Cartwright on the Construction of the Power-House of the Rochester Power Company, adjacent to Genesee Falls, Rochester, N. Y.

The Genesee River drains an area of about 2,500 square miles, and at times pours a flood over the Falls in the city of Rochester, with a volume 293 ft. wide and 5 to 6 ft. deep; the perpendicular fall being 90 ft. By a series of dams the water is used four times before it reaches the level of Lake Ontario.

The paper describes the construction of a power-house close to the Falls, where the great scour made it impracticable to use a timber coffer-dam. This scour was increased by a wing-dam above the Falls, which turned the water toward the side where the power-house was to be built. The rock at the site was undercut by the action of the water, and the first operation was to blast off the overhang to a batter of 1¼ in 10. Operations were carried on day and night, from early in 1890 to November, 1891 (except in freezing weather), since which time the water power has been in use.

The plant consists of two double Leffel wheels, 26¼ in. in diameter, each supplied by a 5-ft. flume under an effective head of 87 ft., with a volume of 6,250 cub. ft. of water per minute, and a development of 600 H.P. by each. The wheels are of phosphor bronze and tinned Otis steel buckets. The power is transmitted from a 5-ft. rope-wheel to a 12-ft. rope-wheel 90 ft. above, through sixteen 1⅛-in. Manilla ropes. The ropes are adjusted by a tightener wheel in an adjustable frame. Each wheel has its own flume and gate, and can be used independently. The ropes run at the very high speed of 7,540 ft. per minute, and no delay has occurred in over a year's use.

The rock at top of the Falls, which is an easily disintegrated shale, overhangs some 20 ft., and the pool below is 40 to 50 ft. deep. The depth at the northwest corner was 10.7 ft., and 13 ft to the northward 22 ft. deep, giving a slope of 45°. The river sometimes rises to half flood in 24 hours, and sometimes when no rain has fallen at Rochester.

A timber coffer-dam in such a location was not to be thought of; and after careful consideration it was decided to use the rock blasted from the overhang above to fill up the pool below. A mass of stone blocks was thus raised 12 to 15 ft. above water and extending outside the foundation. Pumps with 4 and 6-in. suction pipes were used to lower the water. At the point where the solid rock was highest the *débris* was then removed, level benches cut, a heavy footing course laid in Portland cement mortar, and the masonry carried above high water. More broken rock was then removed for about 8 ft. further out, and the irregular spaces filled with dry cement mortar in bags trodden into place. The benching was then done, and the same process followed. By this method, which exposed only a small surface at any one time, all the footings were finally put in and the wall carried above water level.

The cost was less than that of a coffer-dam, even supposing the latter practicable. Stones of 1 to 2 cub. yds. were carried away by the current.

The second paper of the evening was by James Duane, on The Effect of Tuberculation on the Delivery of a 48-in. Water Main. In 1880–81 the writer laid a 48-in. main in Tenth Avenue and Eighty-fifth Street, New York, for the purpose of diverting a part of the flow of the aqueduct into the old Receiving Reservoir in Central Park. This line started from Ninety-third, and ended at the gate-house in Eighty-fifth Street near Eight Avenue.

In 1871–74 the old aqueduct in Tenth Avenue, between Ninety-third Street and One Hundred and Thirteenth Street was replaced by six lines of 48-in. pipe. These mains were all laid true to grade and with curves of 50 ft. radius. At the junctions with the masonry they had converging mouthpieces. They were, however, for some reason, laid without the coal-tar coating now universally applied. The writer, in making the connection of the line laid in 1881 with one of the old mains at Ninety-third Street, found the latter to be tuberculated to a surprising extent. These tubercles were all of the same general shape—that of roughly formed frustra of cones, with a diameter of base of two or three times their height. The largest, which were 2 or 3 in. in diameter and 1 in. high, were, as a rule, found near the bottom of the pipe, but the interior was nearly covered by them.

Bench marks were established on the cover of each manhole and joined carefully by levels, so that direct measurements could be made to the surface of the water, and thus establish its level above datum. As the quantity of water discharged was at this time very uniform and was accurately known, the value of C in the formula $V = C\sqrt{R, I}$ could be quite closely determined. In the aqueduct a value of $C = 135$ gives satisfactory average results, and the flow at this time was 96,000,000 galls. per day. Part of this flow was withdrawn at points above, and a net flow of 92,500,000 galls. per day entered the Tenth Avenue mains, making 18,500,000 galls. for each main. The observed loss of head in a length of 5,992-ft. was 3.39 ft., giving C the remarkably low value of 96, or about 30 per cent. less than that assigned to it in modern practice.

After connections were made between the most westerly of the old pipe and the new pipe laid in 1881, there was a continuous line of 48-in. pipe, of which 5,306 ft. were tuberculated and 4,123 ft. were clean. The observed loss of head in the first was 1.86 ft. and in the second 0.74 ft.; in other words, the value of I in the first was .00035 against .00018 in the second, or about double. Taking C in the first at 96 gave 14,500,000 galls. per day discharge, and this in the new main using I, as determined by observation, gave $C = 134$.

Eleven years later the new main was free from tubercles, and observation showed its discharging capacity unimpaired.

The conclusions are that Croton water will cause bad tuberculation in an uncoated pipe in seven years; that after a cer-

tain time this deterioration does not seem to increase; that a loss of 30 per cent. in discharging capacity is occasioned by the absence of tar coating; or, in other words, that such a coating is worth about $20,000 per mile.

Finally, that after 11 years' service tar coating seems to have perfectly protected the new main from tuberculation.

The Engineering Association of the South held a January meeting at Nashville, Tenn., on the evening of the 12th.

Major W. F. Foster presented a description of the development of the water power at Estill Springs, Tenn. At this point Ell River makes a bend, returning on itself after flowing several miles, the neck of land between the two portions being only 300 ft. across, with a difference of elevation of 12 ft., which is supplemented by a masonry dam raising the water above the bend an additional 12 ft. Across the neck of land a canal is cut which provides for the fore-bay, the wheel-pits, and the tail-race. The power-house of the mills that are to be driven by the power is placed over the wheel-pits. The dam is 300 ft. long between abutments, 5 ft. wide on the crest, is trapezoidal in cross-section, vertical on the upstream side, and battered 6 in. per foot on the down-stream side. It is bedded throughout on solid rock. The masonry is heavy, random, coursed work, laid throughout in hydraulic cement mortar, with a portion of the down-stream stones in each course dowelled to the course below.

Civil Engineers' Club of Cleveland.—At the February meeting Mr. Herman read a paper on "A Weldless Chain," in which he said:

"Oval link welded chain, as used in ship cables for hoisting, is produced in almost the same manner as it has been for several centuries past. Few and but slight improvements have ever been introduced in this industry. Devices intended to supplant this class of chains have never succeeded, for all sacrifice the flexibility at every joint possessed by the ordinary chain. The new chain invented by the writer consists of links each formed of four separable parts—two side-bars and two end pieces. The latter are provided with suitable threaded cavities to receive the screw ends of the former. The links so constructed possess the flexibility of the common chain to the fullest extent. Material and form of each part are selected with regard to the work they have to perform in practical use, while the proportions at each point are determined by the most careful calculation. In this way a link is produced that fulfils all the theoretical and practical requirements of a perfect chain, and is, at the same time, free entirely from the uncertainty of the weld. The different sizes of this chain will be introduced by indicative numbers. These will convey full information as to strength, safe load, and pitch of each size. The chain will be produced ready for use by means of automatic machines invented by the writer. Under the most trying tests this chain has proved its strength and reliability."

JOHN ORTTON.

The reference to the serious illness of Mr. Ortton, which was published in the January number of this Journal, must have prepared those of his friends who read it for the sad news of his death, which occurred on January 6, at his home in Frankfort, Ind.

He was born at Nottingham, England, on March 11, 1825. In March, 1838, he was apprenticed to Mr. William Burlinson, of Sunderland, to learn the trade of a millwright and mechanical engineer. In 1844 he was employed as a fitter in the locomotive works of Robert Stephenson & Company, at Newcastle-on-Tyne. It was at the time that he was working in this shop that his friend, Mr. Williams, invented the link motion. Mr. Ortton wrote an account of this, which was published in the *Railroad Gazette* of Feb. 4, 1881.

In 1847 he was employed in the locomotive department of the London & Northwestern Railway, at Wolverton, in Buckinghamshire. In 1851 he went to the Eastern Counties Railway at Stratford, near London. In 1857 he was engaged as Foreman of the locomotive and car department of the Londonderry & Enniskillen Railway, at Londonderry, in Ireland. From there he went back to the London & Northwestern Railway, as Locomotive Foreman, at Wolverton. This was in 1861. In 1864 he was engaged as Foreman of iron works at Newton Heath, near Manchester, England. In 1865 he was engaged as Manager of the locomotive works of George England & Company, at Hatcham, New Cross, London. Two years afterward he became Manager of the locomotive shops of the London & Southwestern Railway, at Nine Elms, London.

In September, 1873, he left England to take the position of Assistant Mechanical Superintendent of the Great Western Railway of Canada, at Hamilton, Ont., where he arrived on September 16, 1873. Two years after he was appointed as Acting Mechanical Superintendent of the same road. He held this position for one year, and then received the appointment of Mechanical Superintendent of the Canada Southern Railway, with headquarters at St. Thomas, Ont.

In June, 1882, he was appointed General Manager of the Portage, Westbourne & Northwestern Railway, then under construction, with headquarters at Portage, La Prairie, Manitoba. A severe sickness led him to resign this position in 1883, and he then returned to St. Thomas.

In the June following he was appointed Master Mechanic on the New York Central & Hudson River Railroad, in charge of the shops at West Albany. He occupied this position for five years. In the beginning of 1888 and the year following he was engaged as Superintendent of Construction by the American Live Stock Express Company, and was employed by various roads and persons as an expert on special work of various kinds. In May, 1890, he was appointed Superintendent of Motive Power and Rolling Stock of the Toledo, St. Louis & Kansas City Railroad, with headquarters at Delphos, O., but soon after new shops were built for the road at Frankfort, Ind.; he removed his office to that place.

About the first of last November an organic complaint, with which he had been suffering for several years, became worse, and he was obliged to give up all work. The best medical attendance was procured, and hopes were entertained by his friends and family that he would recover; but with the most acute suffering his vitality left him, and he gradually sank and never rallied. His body was taken to St. Thomas, Ont., for burial. He leaves a wife and six children—four daughters and two sons.

Mr. Ortton was an active member of both the Master Mechanics' and the Master Car-Builders' Associations. His genial and pleasant nature made him a general favorite there, and he was popular wherever known. His career is an example of the frequent changes which come to many a man, through no fault of his own, who is engaged in the very uncertain occupation of railroading. Mr. Ortton's career was one of steady advancement, excepting, perhaps, during the last few years of his life, when he bore the burden of ill health. In announcing his death, Mr. Callaway, the President of the company by which he was employed, said of him: "He was a faithful and efficient officer and a fearless and incorruptible man. After life's fitful fever he sleeps well."

His fellow-members of the two associations referred to, especially the older ones, will sadly miss his genial presence, his jovial manners, his sincere, frank, honest nature at their yearly reunions.

PERSONALS.

H. F. Sockridge has been appointed Master Mechanic of the Columbus, Hocking Valley & Toledo Railroad, with headquarters at Columbus, O.

H. A. Gillis has resigned as Master Mechanic of the Port Jervis shops of the New York, Lake Erie & Western Railroad, to become Superintendent of the Roanoke Locomotive & Machine Works at Roanoke, Va.

J. J. Frey has resigned as General Superintendent of the Missouri, Kansas & Texas Railroad to become Vice-President and General Manager of the East Line & Red River Railroad, with headquarters at Greenville, Tex.

A. H. Rudd has been appointed Superintendent of Signals on the Hudson River Division of the New York Central & Hudson River Railroad.

Edgar Van Etten, Superintendent of the Rome, Watertown & Ogdensburg Railroad, has been appointed General Superintendent of the New York Central & Hudson River Railroad instead of Theodore Voorhees, who has resigned.

W. Howard White, C. E., formerly of 74 Wall Street, New York, announces that he has found it expedient to move with his family to a milder climate, and has taken up his residence at Redlands, San Bernardino County, Cal., which will be his future address.

A. A. Allen has been appointed General Superintendent of the Missouri, Kansas & Texas Railroad Company, in place of J. J. Frey, resigned.

Joseph S. Harris has resigned the Vice-Presidency of the Philadelphia & Reading Coal & Iron Company. The resignation was due to the fact that in compliance with the orders of the Chancellor of New Jersey the lease of the Central Railroad

to the Port Reading Railroad was recently dissolved and the managers of the former road have resumed the control.

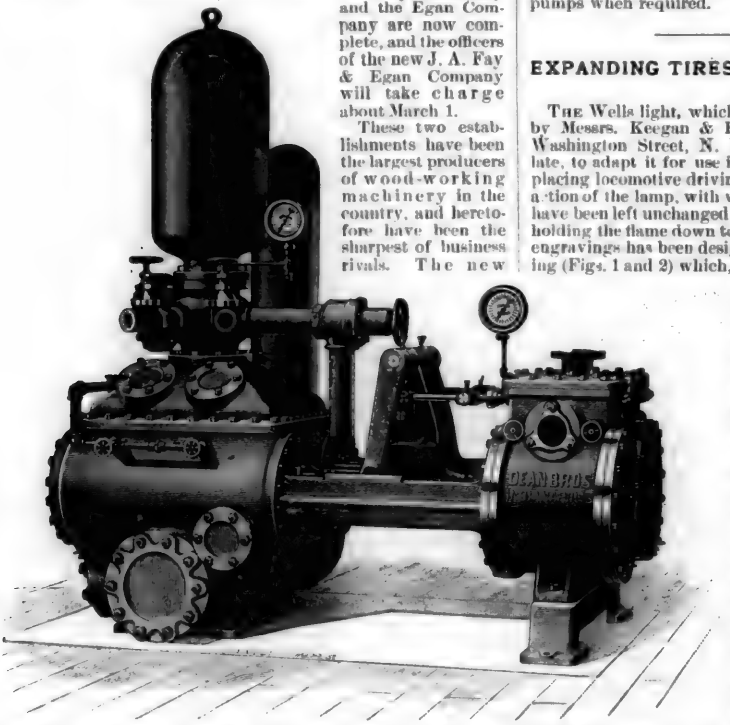
General Superintendent Theodore Voorhees, of the New York Central, has resigned to take the position of First Vice-President of the Philadelphia & Reading. Mr. Voorhees began his railroad work in 1869 in the engineering department of the Delaware, Lackawanna & Western, remaining in that branch of the company's service for about four years. He was then for two years Superintendent of the Syracuse, Binghamton & New York. In December, 1874, he became connected with the transportation department of the Delaware & Hudson Canal Company, and for ten years, up to October 20, 1885, was Superintendent of the Saratoga and Champlain divisions of that company. He left that position to become Assistant General Superintendent of the New York Central, being made General Superintendent at the time Mr. Toucey was promoted to the position of General Manager.

General Notes.

The Indiana Car & Foundry Company held its annual meeting February 7. The financial office of the company is in Cincinnati. Large contracts for cars have been taken, amounting in the aggregate to over $1,000,000. Among these are coal cars for the Pennsylvania Railroad, World's Fair passenger cars for the Illinois Central Railroad, and improved cattle cars for the Hicks Stock Car Company. The works now give employment to about five hundred men, which will be increased to about eight hundred during the next sixty days.

Consolidation of the J. A. Fay and Egan Companies of Cincinnati.—The negotiations that have been in progress for some time for the consolidation of the two great companies of J. A. Fay & Company and the Egan Company are now complete, and the officers of the new J. A. Fay & Egan Company will take charge about March 1.

These two establishments have been the largest producers of wood-working machinery in the country, and heretofore have been the sharpest of business rivals. The new company will probably be the largest of its kind in the world.



The directors of the new company will be Thomas P. Egan, Frederick Danner, W. H. Doane, D. L Lyon, David Jones, W. P. Anderson, Joseph Rawson, S. P. Egan and Edwin Ruthven. Thomas P. Egan will be President and the soul of the enterprise, as he has been of the old Egan Company; Mr. Danner will be Vice-President, S. P Egan, Superintendent and Mr. Ruthven, Secretary. These four officers are of the Egan Company.

Manufactures.

The Standard Fire Pump.

The pump illustrated is one made by Dean Brothers' Steam Pump Works, Indianapolis, Ind., and is constructed from new patterns throughout, in order to conform to the demands of the Associated Insurance Companies for a special fire pump for use in mills, factories, and public buildings, where the premium on insurance risk is based upon the completeness of fire protection furnished by the insured.

These pumps are made strictly in accordance with the specifications adopted by the committee, and are made in four sizes varying in capacity from one stream delivering 320 galls. per minute to four streams delivering 1,000 galls. per minute. They are made of first-class material, and finished and tested to a maximum pressure of 320 lbs. to the square inch at the water end before leaving our works. They have bronze water-piston heads and followers, bronze removable liners in the water cylinders, Tobin bronze piston-rods and valve-rods, bronze, or bronze-lined stuffing-boxes, cushioning valves in steam cylinders, a capacity plate, a stroke gauge, a steam-pressure gauge, a water-pressure gauge, a vacuum chamber, a water-relief valve of large capacity, a set of brass priming pipes and valves, from two to four Chapman hose-valves, and a sight-feed lubricator. The water cylinders have three suction openings. They have large water-valve area, large steam and exhaust passages, suction pipe connections and air chamber.

They are designed for stationary fire-engines, and are reliable, and can be operated at a high rate of piston speed without danger of breaking. A regulator is furnished with the pumps when required.

EXPANDING TIRES WITH THE WELLS LIGHT.

The Wells light, which has been introduced to this country by Messrs. Keegan & Halpin, now William Halpin, of 44 Washington Street, N. Y., has been somewhat modified of late, to adapt it for use in locomotive work for taking off and placing locomotive driving-wheel tires. The construction and action of the lamp, with which our readers are already familiar, have been left unchanged. For the purpose of concentrating and holding the flame down to the tire the apparatus shown by our engravings has been designed. It consists of a sectional covering (Figs. 1 and 2) which, resting upon the flange of the wheel, clasps the tire on either side, and is so constructed that it can be applied to wheels of any diameter, the total length of the section being increased or diminished by the clamps which hook into the slotted sides as shown in the engraving. In this way a single set of sections can be used on wheels varying from 48 in. to 84 in. in diameter. It is simply necessary to jack up the wheels and drop the sections in place.

In regard to the lamp, there have been a few minor changes; in order to make it suitable and convenient for use in connection with this work, instead of the usual upright pipe, carrying the burner at its upper extremity, which throws out the long horizontal flame, the pipe between the tank and the burner is provided with a number of joints, which may be slackened off and tightened so that the burner is readily adjustable and can be held rigidly in any position which may be desired. The burner itself is carried on a pipe turned and fitted to pass through a stuffing-box, so that it may be moved somewhat after the regular pipe fittings have been set; and this stuffing-box is still further fastened by a clamp setting firmly down upon it. The modification in the burner consists in adding one square coil, making three in all, through which the oil (kerosene of 150° fire test) is compelled to pass, and where it is completely volatilized on its way to the burner. One burner remains the same as the regular lighting lamp; the other, where the burner is turned down, has a pipe ex-

tending from the jet end and communicating with the jet itself to the farther coil of the burner; hence, all oil which reaches the jet must rise to the top and come down through this tube, thus insuring its perfect volatilization.

When the apparatus is in use the wheel is entirely surrounded with a sheet of flame; and it is claimed that the tire is more uniformly heated by this method than where a jet of gas is used, because in this instance the flame covers the whole tread of the wheel, and the heat works uniformly inward, so that the center does not receive very much heat, whereas with gas the impingement of the hot Bunsen flame against the center of the tread makes it necessary that the heat should be carried by connection to the farther corners, so that the probabilities are that the center of the inner surface of the tire is heated more rapidly than the corners or the flange, and, consequently, the tire remains for a longer time in contact with the center, which, therefore, receives a greater portion of heat.

THE WELLS LIGHT AS USED FOR EXPANDING TIRES.

A test was made before a number of railroad men and representatives of the technical press at the Kingsland, N. J., shops of the Delaware, Lackawanna & Western Railroad, on February 15. The first four tests consisted in removing the tires from driving-wheels having 57½ in. centers, the tires being 1½ in. thick. The two lamps used were carefully weighed before lighting, and found to weigh 285 lbs. and 280 lbs. respectively. The blaze was turned at 11.36 in the morning, and four minutes later the lamps were adjusted to the tire. In ten minutes the tires had been expanded .08 in. in diameter, and the lamps were removed. In five minutes more the tire had been swung clear of the wheel and was on its way to the scrap heap. In the second test the lamps were burning in contact with the tire for 14 minutes, and the tire was off 3½ minutes later. The third test the lamps were burning for 12 minutes, and 2½ minutes more were required for the removal of the tire. The fourth test occupied 12 minutes for heating and 2¾ minutes for

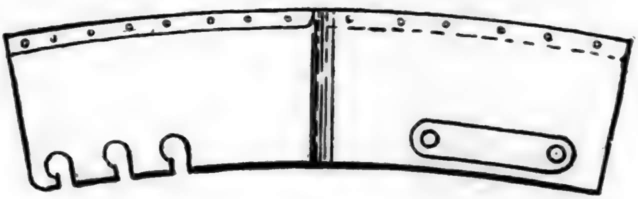


Fig. 1.

Fig. 2.

the removal of the tire. The last tire was removed in just exactly 61 minutes from the time of the application of the first lamp to the first tire, thus finishing at the rate of about four tires per hour.

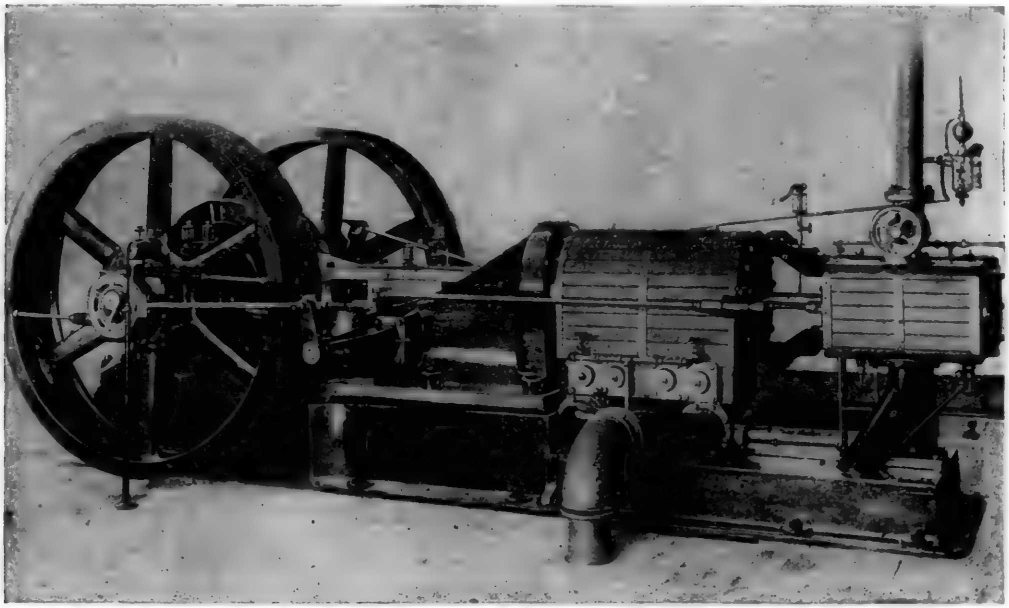
The next two tests were those of heating tires for application to wheels of 44-in. centers, the tires themselves being 3¼ in. thick. These were also expanded so that their diameter was increased .08 in. The lamps were burning against the tire for 11 minutes, and 2 minutes were required for the adjustment of the tire. In the second instance the lamps were burning for 10 minutes, and the tire was in position 2 minutes later. The apparent reason for the greater length of time required for heating the third and fourth tires over the first, fifth and sixth lies, probably, in the fact that when the first named were reached the tank pressure had fallen from 25 to 20 lbs., and was again pumped up to 25 lbs. before doing the work on numbers five and six. After the tests the tanks were again weighed, and it was found that one had consumed 47 and the other had consumed 41 lbs. Taking the oil as weighing 6½ lbs. to the gallon, we have a total oil consumption for the 88 lbs. of 13.5+ gallons. It must be taken into consideration, however, that whereas both lamps were burning for 2 hours and 30 minutes, there was an interval of 40 minutes between tests four and five, when no work was being done. So we have the oil consumption in actual service reduced to 64½ lbs., or 9⅞+ gallons. As this oil costs six cents a gallon, the cost for heating the six tires is 58½ cents. The temperature of the flame has not been accurately determined as yet, but it is believed that it is sufficiently high to heat locomotive flames for straightening while still in position upon the engine, and work of this kind will be attempted very shortly. The expansion of the tire for the 44-in. center by .08 in. shows an increase of temperature of about 205°.

ARMINGTON & SIMS' TANDEM COMPOUND ENGINE.

Among the large variety of engines turned out by the Armington & Sims Engine Company the tandem compound, herewith illustrated, is meeting with great success, particularly for the heavy, variable duty of the electrical railroad service. These engines are built very heavy—large shafts, wearing surfaces ample, heavy balance wheels, and, in fact, every part is designed especially for the hardest duty.

The particular engine illustrated above is one of two in use by the Worcester & Millbury Railroad, and is of 250 H.P.; cylinders, 13 in. and 24 in. × 18 in.; speed, 200 revolutions; wheels, 86 in. in diameter. It has a steam-jacketted receiver, and the high-pressure cylinder is also steam jacketted. It is self-contained, having a base under engine which is extended to support the cylinders. The low-pressure cylinder has four Corliss valves worked by a very simple and efficient device.

The company is now building engines of this type from 150 H.P. to as large as 900 H.P. The details of these engines seem to be particularly well worked out, and it is useless to speak of the workmanship, as this company aim to furnish nothing but the best. The Jarvis Engineering Company of 61 Oliver Street, Boston, Mass., are the Eastern agents for the sale of the Armington & Sims engines, as well as contractors for complete steam plants.



ARMINGTON & SIMS' TANDEM COMPOUND ENGINE.

AN ENGLISH LOCOMOTIVE FOR SUBURBAN TRAFFIC.

The accompanying illustration, from the London *Engineer*, shows a tank engine for suburban and mixed traffic built for the London, Tilbury & South End Railway on the designs of Mr. Thomas Whitelegg, Locomotive Superintendent. It has four driving-wheels coupled, and all placed under the barrel of the boiler; the front end is carried by a four-wheeled truck, and behind the fire-box is a pair of bearing wheels with radial axle-boxes. The cylinders are outside and are horizontal. Water is carried in two side-tanks, and there is a small tank on the foot-plate, where the coal-box is also placed.

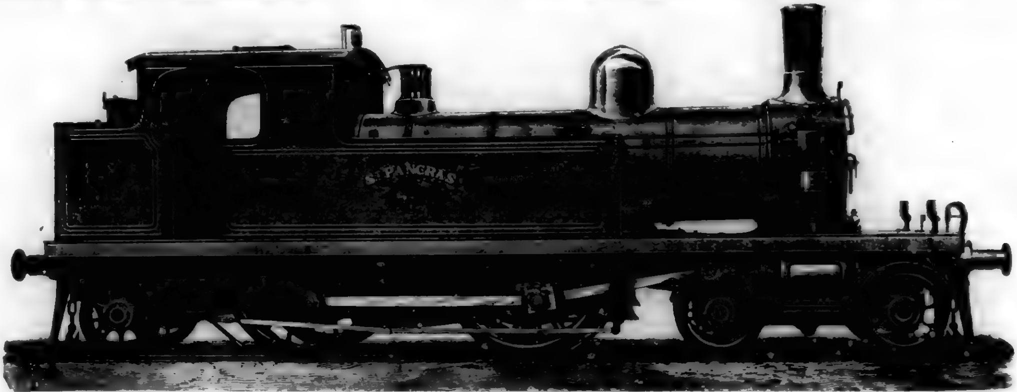
The boiler barrel is 49 in. in diameter and has 189 tubes 1⅝ in. in diameter. The grate area is 17 sq. ft., and the heating surface is: Fire-box, 97; tubes, 914; total, 1,011 sq. ft. The working pressure is 160 lbs. The tanks hold 1,300 gallons of water and the coal box two tons of coal.

The cylinders are 17 in. in diameter and 26 in. stroke. The driving-wheels are 73 in. in diameter. The truck wheels and the trailing wheels are 37 in. in diameter. The steam-chests are on the inner sides of the cylinders, in the smoke-box. The frames are of the usual English plate type. The driving wheel-base is 8 ft. 6 in., and the total wheel base 29 ft. 4 in.

The total weight of the engine in working order is 126,350 lbs., of which 36,250 lbs. are carried on the truck, 71,850 lbs. on the driving-wheels and 18,250 lbs. on the trailing wheels. The engine is fitted with the Westinghouse air-brake and has driver-brakes.

Band Resawing Machine.

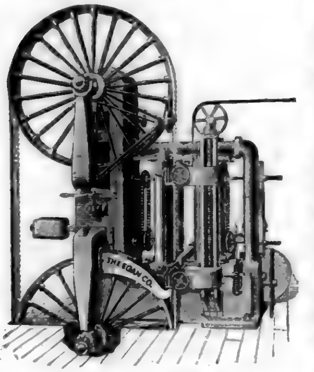
We illustrate a new band resawing machine with a capacity of 35,000 ft., made by the Egan Company, of Cincinnati, O. It is easy to handle and not liable to get out of order, and can be run in a saw-mill in connection with a band saw or with a circular, using the circular for squaring up the logs and reducing the timber to boards on the resaw.



ENGLISH TANK LOCOMOTIVE FOR LOCAL TRAFFIC.

The wheels are 80 in. in diameter, of solid metal, having steel spokes placed in the hub and rim in such a position as to insure the greatest amount of strength. Each wheel is fitted to its shaft in a superior manner, perfectly balanced; the lower wheel being made thicker and heavier in the rim is given thereby an increased weight and momentum, and is an improvement of more than ordinary value. Each wheel shaft is supported by an adjustable outside, heavy bearing outside of each wheel.

The feed is very powerful, consisting of two pairs of feed rolls of large diameter and driven by powerful gearing; each pair of feed rolls is operated independent of the other, and supported at the top and bottom by large screws, making it impossible for the rolls to get out of line with the saw when sawing warped or irregular stock. The graduating feed is at all times under control of the operator, enabling him to increase or diminish it by moving one lever.

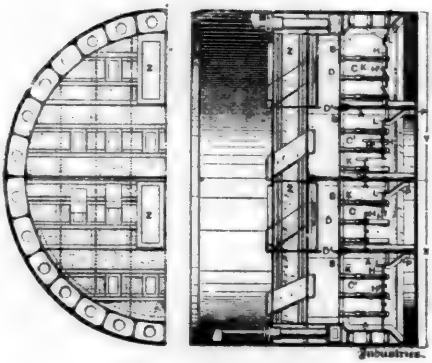


EGAN BAND SAW.

The roller guides are of new design, and the upper guide is connected to an upright bracket moving up and down on same and counter-weighted. It will resaw stock up to 48 in. wide and to the center of 24 in., or will cut a thin sheet or board from the side of a timber 12 in. thick. When cutting narrow stock, the entire width of cut can be made by placing several pieces of stock between the rolls, one above the other.

A NEW TUNNELING SHIELD.

The accompanying cut shows a form of tunneling shield recently patented in England by G. & W. D. Pearson, of Westminster. These inventors aim at constructing tunneling shields for use in tunneling through water-bearing strata in such a manner as to provide for the men working in safety in case of an inrush of water, to prevent the lining becoming displaced before or during the process of filling up between it and the tunnel, and to provide for the process of excavating to be carried on in stages, in each of which the work is done vertically. Fig. 1 shows a half elevation of the shield looking from the tunnel, and fig. 2 is a longitudinal section of the same. The shield itself is, as regards its outer formation and as regards the method of driving it forward, of the same construction as those heretofore employed. *A A* are transverse floors of any number, fitted equidistant apart and dividing the interior of the shield into any number of compartments, and *B B* are hanging curtains, the space in front of which forms the working chambers *C C*[1], while behind these chambers are safety chambers *D*, arranged alternately behind the former. The man in the lower working chamber of each pair has always, when there is an inrush of water, an air space in front of the curtain *B*. A way, D^1, is cut in the floor of the safety chamber above him for him to climb up through, and a suitable doorway, *E*, is provided through which the workmen can escape into the air-lock *Z*. This doorway is at a sufficiently low level to leave head-room and a breathing space of sufficient capacity to prevent his being drowned by the water, which latter will be kept back by a volume of air in the safety chamber, the pressure of which will equal that of the water. The front of each working chamber is made up with pollings or shutters *H*. These are of any convenient cross-section, carried by a suitable number of rams *K* or screws, and are supported from behind in any convenient way. The adjacent edges are provided with suitable packings H^1. H^2 are flexible webs made of sail canvas, rubber or other material. The bottom edge of the lowest polling in any one compartment may be made practically water and air-tight by flexible rubber flaps, or other suitable device, or by clay packing. A flap, *L*, is hinged to the top of the shutter in such a way that it can be pushed outward and downward by the man so as to give him free access through the excavating opening to the stuff to be got out and also to act as a water



PEARSON'S TUNNELING SHIELD.

LOCOMOTIVE RETURNS FOR THE MONTH OF NOVEMBER, 1892.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage.					Av. Train.		Coal Burned per Mile.						Cost per Locomotive Mile.							Cost per Car Mile.		Cost of Coal per Ton.
			Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Passenger Cars.	Freight Cars.	Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Passenger.	Freight.	
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé	834	739	....	....	401.701	2,312 940	3,130	....	....	....	....	....	87.26	....	....	4.91	6.73	0.27	0.14	6.79	1.50	20.34	....	....	1.48
Canadian Pacific*	606	....	466,788	825,779	515,889	1,808,445	2,984	....	....	....	....	....	72.28	....	....	3.40	12.21	0.30	....	5 38	1.24	22.62	....	1.96	3 35
Chic., Burlington & Quincy	528	....	....	....	....	1,814,281	3 436	4.87	18.54	....	....	....	90.86	....	....	4.32	6.29	0.23	0.30	6.74	....	17.88	....	....	1.39
Chic., Milwaukee & St. Paul	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Chic., Rock Island & Pacific	553	....	548,181	982,393	409,242	1,939,816	3,508	....	....	....	....	....	68.89	....	....	2.75	6.13	0.28	2.75	6.02	0.42	15.94	....	....	1.64
Chicago & Northwestern	888	....	686,188	1,451,416	789,136	2,926.740	....	....	....	....	....	....	88 41	....	....	3.35	7.94	0.34	....	6.37	0.88	18.83	....	....	1.78
Cumberland & Penn	22	22	5,250	39,610	....	44,860	....	....	....	....	....	....	90.09	....	....	4.07	4 84	0.40	....	....	....	....	....	....	1.83
Delaware, Lackawanna & W. Main L.	208	193	....	....	....	680.701	3,527	....	....	....	....	....	92.72	....	....	2.97	7.30	0.42	....	5.81	....	16.50	....	....	....
Morris & Essex Division	159	..	166,857	231,862	12,523	411,242	2,586	....	....	....	....	....	64.43	....	....	4.14	10.12	0.39	....	6.42	....	21.07	....	....	3.09
Hannibal & St. Joseph	....	60	74,461	160,552	36,567	271,580	4,115	5.41	16.42	....	....	....	97.28	14.73	7.71	4.01	6.88	0.24	0.30	7.01	....	18.44	....	....	1.44
Kansas City, F. S. & Memphis	149	....	98,569	262.926	124,384	485.879	3,260	....	....	....	....	....	66.64	....	....	3.21	5.44	0.23	0.48	7.34	....	16.70	....	....	1.60
Kan. City, Mem. & Birm	41	37	35,355	62.890	12,098	110,340	2,982	....	....	....	....	....	65.55	....	....	2.44	3.71	0.24	0.49	7.(6	....	13.94	....	....	1.08
Kan. City, St. Jo. & Council Bluffs	41	....	57,545	41,457	43,868	142,870	3,485	5.00	21.78	....	....	....	66.49	18.35	4.74	2.21	6.38	0.14	0.31	5 97	....	15.01	....	....	1.95
Lake Shore & Mich. Southern	589	....	426,934	849,043	625,968	1,901,945	3,229	....	....	....	....	....	....	....	....	3.02	5.32	0.13	0.50	6.97	0.18	15.67	....	....	1.54
Louisville & Nashville	346	....	416,706	850,624	398,793	1,666.123	3,663	5.11	18.77	68.58	116.51	52.06	....	18.50	5.97	4.23	7.00	0.26	0.85	6.11	0.57	19.57	3.36	1.26	1.59
Manhattan Elevated	....	292	744,504	....	53,266	797,770	2,732	....	....	....	....	....	46.13	....	....	2.30	9.20	....	0.30	8.80	....	20.60	....	....	3.90
Mexican Central	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Mil., L. S. & Western	....	112	76,940	133,715	76,121	286.776	2,578	....	....	....	....	....	79.33	....	....	3.44	11.29	0.25	....	6.23	0.97	22.18	....	....	2.80
Missouri Pacific	329	313	....	....	....	1,187,3?7	3,787	4.48	16.99	....	....	....	80.67	15.55	6.88	5.37	6.50	0.33	1.09	6.42	1.47	21.18	4.42	1.46	1.42
N. Y., Lake Erie & Western	....	624	445,642	924,921	291,042	1,661.605	3,023	4.50	22.70	90.80	184.8	71.20	....	20.10	6.00	4.68	7.59	0.38	2.10	7.30	1.15	23.20	....	1.68	1.86
N. Y., Pennsylvania & Ohio	....	250	132,516	428,439	153,724	714,679	3,455	5.40	18.10	84.20	133.0	79.60	....	15.70	7.30	3.90	6 49	0.30	1.72	6.66	1.02	20.31	....	1.71	1 15
Norfolk & Western, Gen. East. Div.†	....	148	97.986	259,631	57,854	415,421	2,788	4.50	19.00	....	....	....	102 07	....	....	9.00	3.70	0.70	....	....	....	13.40	....	....	....
General Western Division	....	122	68,586	237,609	25,442	331,637	2,632	4.50	14.90	....	....	....	129.03	....	....	13.60	4.50	0 80	....	....	....	18.90	....	....	....
Old Colony	....	226	333,323	129,027	126,281	598,631	2,649	....	....	....	....	....	62.92	....	....	2.88	11.81	0.64	....	6.75	0.79	22.87	....	....	3.75
Philadelphia & Reading	....	....	466.485	828,700	620,444	1,915.629	....	....	....	....	....	....	81.23	....	....	3.72	4.81	0.31	....	6.00	0.39	15.23	....	....	....
Southern Pacific, Pacific System	....	721	....	....	....	1,740,198	2,414	....	....	....	....	....	70.42	....	....	5.02	17.71	0.41	1.71	7.29	1.19	33.89	....	....	5.11
Union Pacific	....	991	698.074	1,583,719	514.812	2,796.605	2,822	5.51	17.46	....	....	....	99.90	....	....	7.04	9.18	0.40	0.84	8.10	1.08	26.59	4.53	1.87	1.82
Wabash	419	362	394,584	687,853	311,900	1,894,337	3,855	5.01	17.55	....	....	....	91.74	14.72	6.41	3.46	4.68	0.30	....	6.37	0.85	15.66	2.65	1.02	1.02
Wisconsin Central	150	123	119,784	236,833	17,095	433,112	3,521	....	....	....	....	....	88.37	....	....	3.83	10.57	0.27	....	7.16	....	21.83	....	....	2.36

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

seal. The outer edges of the pollings are packed to the sides of the shield in the following way: Chambers are formed around the working chamber of a suitable length to meet the requirements of the travel above mentioned by means of two angle-bars, one M fixed to the shield, and the other N to the polling. The flange of the angle on the latter, which is next to the shield, rests and slides upon the angle on the shield, thereby closing in the chamber. This is filled with clay or puddle, and as the travel begins the clay escapes through suitable openings, but suffers sufficient compression to insure a tight joint. The leading edges of the floors, as well as the edge of the shield are provided with plows P which, as they advance, readily loosen the stuff immediately adjacent to them. The side edges may also be fitted with plow edges if the nature of the soil render such a construction desirable. The shield is subdivided vertically into two or more compartments X Y, and these two form two air-tight chambers, into which air can be delivered at a pressure suitable to the hydrostatic head existing in each of the compartments of the shield so subdivided.—*Industries.*

H. K. Porter & Company's Distribution of Profits to Employés.

THIS firm of locomotive builders has recently made the eighth voluntary distribution to their employés. In their circular announcing this distribution, it is said:

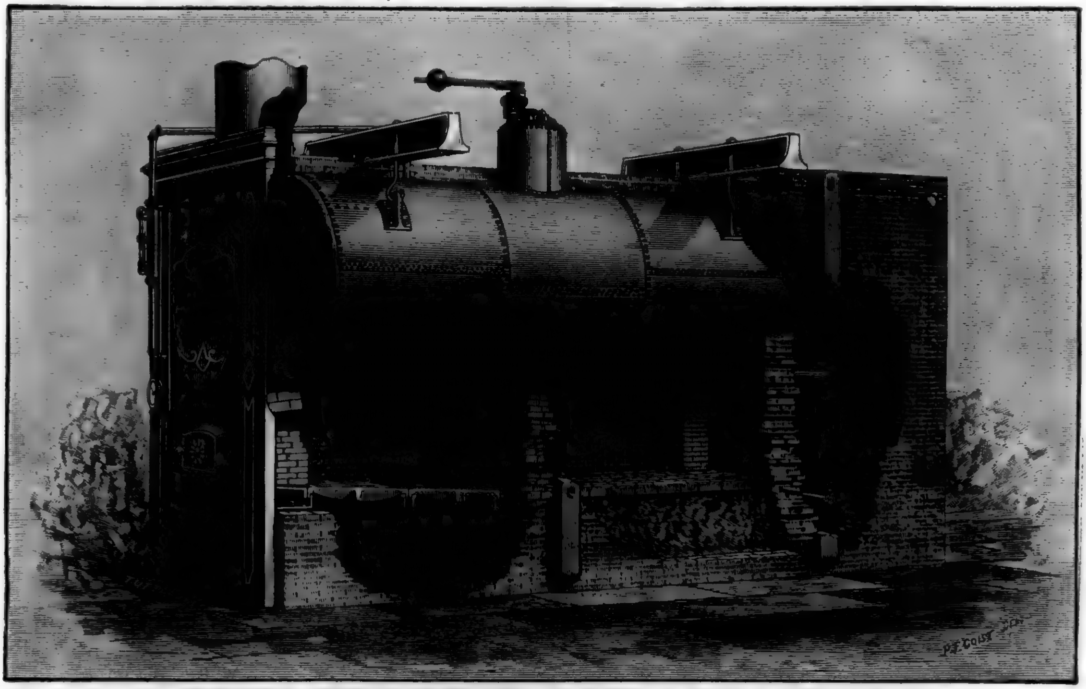
"The conditions of business the past year have been very trying, and in many respects discouraging. Prices were less throughout the year than in 1891, and the output for the first six months was very small. But as soon as the demand increased the output largely increased, and by your efficient co-operation, so soon as you had the opportunity to put it forth, we largely recovered the lost ground. This proves to us what we believed before, that practical co-operation is a positive benefit to every one of us, and that it pays us partly, if not fully, in the item of dollars and cents, to make this distribution. We have often said to you that it is only on this basis that we can hope to make such distribution a permanent annual thing. But such reasonable return to us only makes us the more gratified to recognize your efficient and cheerful service, and to be able to give you this additional remuneration for your faithful labor. We hope that in receiving this sum, each one of you is conscious of having deserved it by having rendered the best service in his power; and that the money will be a positive good to each one, and to all dependent upon you.

"Hoping for your individual good in every way in the future, we remain,

"Your friends,

"H. K. PORTER & COMPANY."

Such evidence of amicable relations between employers and their men lead to the thought that the millennium is not an impossible event.



HORIZONTAL TUBULAR BOILER, BY THE ROBERT POOLE & SON COMPANY.

Poole's Horizontal Boiler.

THE accompanying illustration shows a horizontal tubular boiler and setting by the Robert Poole & Son Company, Baltimore. The boiler is given, not so much for any special feature, as to show the excellent arrangement of tubes and the general good proportion of the setting and general arrangements.

The engraving shows the boiler with furnace front and masonry, one of the side walls being removed to show the arrangement of grate bars, bridge walls, damper, tubes, etc. The flame passes under the boiler and returns through the tubes. These boilers are constructed of best materials and workmanship, the tube-sheets especially being of very superior materials, manufactured expressly for the purpose. The tubes are arranged so as to provide for the freest possible circulation of the water, and a manhole is placed in the lower part of the front head, so that the boiler may be cleaned with convenience and thoroughness. The mountings consist of furnace front, grate and bearing bars, flue chamber doors, wall plate, bolts and rods, safety-valve, steam-gauge, gauge cocks, and blow-out and feed cocks.

NAVAL OBSERVATORY TELESCOPE.

THE new telescope for the Naval Observatory at Washington has recently been completed by Warner & Swasey, of Cleveland, O., the builders of the famous Lick instrument. It is entirely new, with the exception of the fine 26-in. object glass, and in power is second only to the Lick in this coun-

try, and is excelled by but two telescopes abroad—the Vienna instrument and the one at Pulkowa, Russia.

The new telescope will weigh 30 tons, about two-thirds of which comes from the cast-iron rectangular supporting pier, in which is built the great clock for driving the telescope in either stellar, solar, or lunar time. By it the star under observation is kept in exactly the center of the field of vision for hours at a time, and it is possible to leave a photographic plate exposed three or four hours with the same results as if the tube and star alike were stationary.

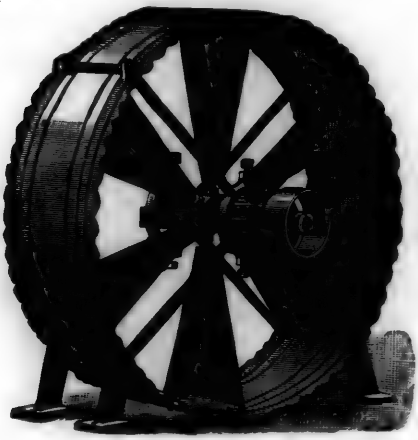


Fig. 1.

The tube itself is of sheet steel, 38 ft. long, 26 in. in diameter at the object glass, 31 in. at the center, and 24 in. at the point where the eye-piece is placed. The sheets vary in thickness from one-tenth to one-twelfth of an inch, and have been carefully tested, with a view to bearing all the strain put upon them and maintaining a perfect tube. There is no ornamentation, by polishing or otherwise, except plain black paint. The weight of the tube is 2,000 lbs.

The telescope is equipped for photographic and spectroscopic work, and is very complete in all its appliances. One observer will be able to handle the great instrument easily and quickly, so fine and perfect are the adjustments and machinery. The difficulty met in observing a star when it is low in the heavens and the eye-piece is brought high above the floor is overcome by raising the floor by hydraulic rams. The observer touches an electric button in a keyboard by his side and raises or lowers the floor at will.

The clock is wound automatically by electricity. When the weights reach a certain point they switch on an electric current, which is cut off again when they are wound up.

The ease in handling the telescope is increased by the devices to reduce friction. The shaft of the polar axis rests on hardened steel ball bearings resembling those in fine bicycles, and at the top it works on a necklace of anti-friction rolls.—*New York Times.*

WING'S DISK FAN.

We illustrate two forms of disk exhaust fans made by L. J. Wing & Co., of 126 Liberty Street, New York. Fig. 1 shows the ordinary fan designed to be driven by a belt. The advantages claimed for this fan are that, inasmuch as the blades are curved and have an expanding pitch, the amount of air removed is increased, while the slippage is lessened. The amount of power required to run the fan is very little, and as the fan and its working parts are enclosed in a framework protected and held together by arms of wrought iron, there is no danger of accident.

The blades are also adjustable, so that they may be set to suit the conditions under which the fan is to operate, and it may be used efficiently under widely varying conditions. Its light weight enables it to be placed at either end or in the center of a pipe, in a wall, window, or door, where it may be run either horizontally or vertically as circumstances may require. Finally, it is noiseless. The applications of the fan embrace about everything where a draft of air is required, as in drying-rooms for silk and woolen goods, for removing steam, vapors, smoke, heat, gases, dust, acids, and for ventilating vessels, mines, and tunnels.

Fig. 2 illustrates a large fan with a special engine attached for driving it. The engine is placed on the fan-frame and connected to the shaft, thus forming practically a part of the fan. It is neat, compact and light, and runs with very little care, and is very desirable for places where there is steam but no engine, where the fan is to be placed in some isolated spot, or is to be run at night when the main engine is shut down, and is very convenient for night drying in factories or for heating buildings.

A Large Hydraulic Ram.—Rife's Hydraulic Engine Manufacturing Company, Roanoke, Va., has recently built a hydraulic ram which yields remarkable results. It is attached to an 18-in drive pipe with a 4-in. discharge-pipe, and weighs a ton. This ram, under a head of 7 ft., elevated a gallon of water per second to a height of 34 ft. It is said that during the experiment the ram took in the requisite quantity of air and worked very steadily and satisfactorily. It has thus been demonstrated that it is quite within the range of possibilities to make larger hydraulic rams than have heretofore been thought of.

Belt Railroad at Terre Haute, Ind.—There is a movement on foot at Terre Haute, Ind., to build a belt line connecting the various roads centering in the city. A charter was granted for such a road in 1883 for fifty years, but it was decided at that time that the city was unable to support such a road. Now, however, the city has so encroached on the yards, which were built outside of the city at that time, that the officials of the roads interested are strongly in favor of the line. It is estimated that the proportional cost to all the roads interested will be comparatively small, and that the location of the new factories will increase the rates and pay the cost of construction in a short time.

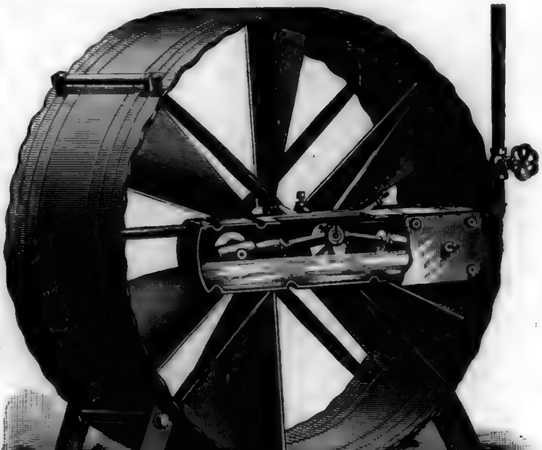


Fig. 2.

The Ajax Metal Company Incorporated.—This Company announces that the co-partnership heretofore existing between J. G. Hendrickson and F. J. Clamer, which has conducted its business under the name of The Ajax Metal Company, is this day dissolved by mutual consent.

The property and interests of said co-partnership have been acquired by The Ajax Metal Company, Incorporated, which will continue the business.

The officers of The Ajax Metal Company, Incorporated, are: J. G. Hendrickson, President; Francis J. Clamer, Vice-President; and J. R. Nelson, Secretary and Treasurer.

The business will be carried on in Philadelphia as heretofore.

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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EDITORIAL NOTES.

THE sailing of the reconstructed *Viking* ship across the Atlantic in May promises to be of far more value and to possess a scientific interest that has not yet been touched by the foolhardy voyages in dories. The vessel has been built upon the lines of the original ship unearthed at Sandefjord, and is 17½ ft. long, with a beam of 16½ ft.

SLOWLY we are coming up to do some things that they are doing abroad. Hydraulic machinery has received a wide application in London and Liverpool for years. Pneumatic tubes are used for the transmission of parcels in every capital of Europe; and now we learn that a large manufacturing house is about to put a complete line of high-speed hydraulic motors upon the market, while successful experiments have been conducted with a pneumatic tube service in Philadelphia.

THE report of the board appointed to test the guns of the *Vesuvius* appears in another column, and practically bears out the criticism of the work done which appeared in our March issue. It says, in substance, that while the accuracy of aim was satisfactory, and it has been proven possible to fire dynamite in the manner proposed with safety to the crew, the details of the mechanism need some modification and the fuse is inadequate for the work required of it. In short, that the *Vesuvius* can probably be made effective by the expenditure of more time and money, but that at present the craft is not all that is to be desired.

THE rapid development of electric railroading within the past few years has led to their extension in such a way as to make them competitors of the steam roads in some localities. And now the New Hampshire Commissioners present a protest against the granting of franchises to electric roads for the right to use the public highways, on the ground that the steam corporations, with whom the electric road enters into competition, is required to, buy its right of way, construct and maintain its roadbed, bridges, and fences, and there is no good reason why the competitor, whose business is exactly the same, should be given a roadway and furnished with a roadbed, bridges, and fences at the public expense.

THE COMFORTS OF RAILROAD TRAVEL.

ABOUT two years ago an editorial article on the Discomforts of Railroad Travel was published in THE RAILROAD AND ENGINEERING JOURNAL. The *raison d'être* or reason for existence of that editorial was stated in the following introduction, which has probably been forgotten by most of those who read it, and will be new to those who did not, and may therefore serve again as a preface to what will follow here. The prefatory observations were as follows:

In an admirable essay on Organization in Daily Life, the author, Sir Arthur Helps, said:

If you want to improve the administration of railways, I will tell you how to do it. Look out for a very ingenious, sickly man, with a large family, and give him $4,000 a year as an inspector of railways. Let him make short reports, in good English, of his sufferings on different railways, specifying names, dates, and every particular. He must be bound to travel occasionally with his whole family, in the depth of the winter. We do not know of their sufferings sufficiently in detail. An ordinary person would be ashamed to describe these minutiæ; but it must be this man's business. Besides, seriously speaking, he would meet with great differences of treatment. One thing is well managed on this railway, another on that. He would be able to praise as well as to blame. There is one railway I know of on which, to my judgment, the coupling of the carriages is not sufficiently attended to. There is another railway on which I have never found the same fault. My inspector would tell the world these things, and an effect would be produced upon the traffic of these lines.

Probably few of the subscribers of this JOURNAL will read the above suggestion without feeling a desire to be appointed such an inspector, not alone for the salary of $4,000, but from a sort of instinct of reform which most active-minded people feel, and which manifests itself in a longing to set those things right which, in their judgment, are going wrong. While such an appointment and salary would not be easy to get, any of us may indulge in the hypothetical exercise of the duties and privileges of the office, without the salary. The writer has a sufficient amount of overweening vanity to imagine that he has some of the qualifications required of such an inspector. He is sufficiently ingenious to be called a "crank," and though not exactly sickly, he has a digestive apparatus which does not consume its fuel as successfully as a locomotive with a

brick arch does.* He has not a large family, but he nurtures a brood of cares, anxieties, duties and responsibilities which he takes with him in his travels, and which are, perhaps, as troublesome as a family of children would be. He can make a report in English, which competent critics would reject as a model of style, but it has the merit of being comprehensible. He therefore assumes the office of a self-appointed inspector of railroads, and submits this as his

SECOND REPORT.

Persons old enough to remember how people traveled 50 years ago and the travail attending it, and who now have occasion to take a journey on any of our main lines of railroad, cannot help but compare the discomforts of a journey in those early days with the luxuries which may be enjoyed now. Then many journeys were made with no other protection from the elements than the sky or the clouds above the traveler, and a saddle and horse below him. It is true that there were some ills about which we complain a great deal that he did not suffer from. Bad ventilation is one of these; par-boiling by steam heat, another. It is said that the best thing for the inside of a man is the outside of a horse, so that our ancient equestrian travelers' lot may not have been as bad as it now seems to us. It may be, too, that the jolting of a stage-coach had a beneficial effect on the jolted, analogous to that of the Swedish movement cure; but it would perhaps be hard to convince weary passengers of it after they had been jolted, bounced and bruised in one of the old-fashioned vehicles on a rough road for many hours.

To-day all this is changed. If we are democratic and economical, or economical without being democratic, we can have a more or less comfortable seat in a car which does not jolt disagreeably, in which we are completely protected from the elements, the vehicle is warmed more or less comfortably, and at night lighted, so that if we have good eyesight we can see to read. We have large, clear windows from which, excepting in some execrable drawing-room cars, we can "view the landscape o'er." Instead of traveling at a speed of from four to six miles an hour, we go about 10 times as fast. At night we can stiffen our backbones and wriggle into more or less uncomfortable positions and snatch such periods of slumber as may be possible under the circumstances. All that can be said, though, for this kind of rest is that it is not quite as uncomfortable as trying to sleep on horseback or in a stage-coach.

If we are not disposed to be overmuch economical, we can have greater comfort and more luxuries than an ordinary day coach affords. We may engage and pay for a berth or section in a sleeping-car, and, at night, enjoy the rest which a more or less comfortable bed will afford, and in the daytime—if we indulge in the luxury of a whole section—may have the exclusiveness which is afforded by an apartment reserved for our own use, which gives ample room for the disposal of our "traps" and for the stretching of dependent limbs. The seats are almost ideally comfortable. They are of ample width, the lower portion of the backs is curved to fit the shape of the spinal column, and the upper part is formed to support the shoulder blades. In the Wagner cars the seats are inclined backward, so that a person sitting in the seat thus occupies a static position, and is without any dynamic tendency to slide out of it. The Pullman Company does not seem to have grasped the law which governs the involuntary action of the human body when it occupies a horizontal seat, and all or nearly all the seats in its sleeping-cars are without any backward inclination.

It is said of some English statesman who was very much overworked, that when he became exhausted he would take a journey from London to Edinburg in a first-class railway carriage, as he found that nothing rested him as that did. The diversity of scene, the rapid and easy motion, the rest which was given by the pre-eminently comfortable seats in an English first-class carriage, the separation from the intrusion of letters, telegrams and bores—all conspired to retard the wheels of thought and rest the weary body. To the overworked in this country there is nothing like a day journey in a first-class sleeping-car for a temporary rest. It is to be regretted that such cars cannot be so highly recommended, and that they are much less comfortable for night travel, the purpose for which they are intended.

A little criticism—the result of observation during a recent journey—may not be inappropriate here. The "final cause," as the metaphysicians would say, of a sleeping-car is to enable people to sleep in them, one prerequisite to which is a comfortable bed. Now it is a matter of general repute, which is the result of much experience, that sleeping-car beds are not comfortable. They are generally hard, inelastic, and make one's bones ache by reason of the jolting of the car. A little analysis of their construction will show the reason for this.

What may be called the permanent way of the bed is the seat and back cushions. The former of these must support the passenger in daytime, when he is sitting upright. In this position his bearing surface on the seat is probably about one-half of a square foot. The springs and upholstery of the cushion must therefore be made stiff enough so as to support a weight of from 100 lbs. or less up to, say, 250 lbs., on a half of a square foot of its surface. At night this same cushion forms part of the substructure of the bed. In a recumbent position an occupant of a bed has about 10 times more bearing surface on it than a sitting passenger has on a seat. Consequently a seat should be about 10 times as rigid or stiff as a bed, or, conversely, the bed should be 10 times as yielding or elastic as the seat. Now, in ordinary sleeping-cars the seat cushions must do duty both in daytime and at night. From what has been said, it is obvious that it is not equally well suited for both uses. As the back cushions of seats need not support the weight of passengers for day use, they may be made much softer than the seat cushions, and in ordinary day cars they are usually made so; but in sleeping-cars they form the head or foot portion of the bed, and as the seat cushions form the middle, the backs must be made as hard as the seats, otherwise there would be a diminutive mountain in the middle of the bed, with a valley at each end. For this reason the back cushions of sleeping-cars are made nearly or quite as hard as the seats, which makes the former uncomfortable both in daytime and at night. Now what seems to be needed is a seat cushion which will be sufficiently elastic or soft to make a comfortable bed at night, and with enough rigidity to be able to support heavy passengers in daytime. Then the back cushions might also be soft, which would make them more comfortable both in daytime and at night.

These requirements for seat cushions may seem to be contradictory or incongruous. We have Herbert Spencer's authority for the statement that "all organic evolution consists in a change from the homogeneous to the heterogeneous," and that "every existing organism has been developed

out of the simple into the complex," and that the functions of organisms become "differentiated." Now, in order to solve the difficulty with the seat cushions, it is proposed to "differentiate" the functions of the seat springs. It should be kept in mind, though, that what is said here is merely suggestion, and is not offered as a complete solution of the problem. Before that stage is reached experiment, adaptation and improvement of details will be required.

The differentiation referred to is that *some* of the springs of seats should be made to carry the weight of occupants of the bed at night, and others or all should support the passengers in daytime. Supposing that the seat cushions were provided with springs whose tension when they are all compressed to a length of, say, 3 in., would be sufficient to support an occupant in a sitting posture. Suppose, further, that when the seat is upholstered every alternate spring is drawn down so as to be compressed to 3 in. in length, and that the intervening ones were permitted to extend to, say, 5 in. Now attach the surface upholstery—hair, canvas, plush, etc.—to the extended springs in such a way that they alone would at first bear the weight of a person sitting or lying on the cushion. When used as a seat the extended springs would be compressed, until they are compressed to 3 in. in length. The weight of the person sitting on the seat would then bear on the intervening springs, and it would be equally distributed on all the springs in the seat. If used as a bed, the extended springs alone would be sufficient to support that part of the weight of the sleeper which would rest on them. Another suggestion which may occur to some of our readers is to have two tiers of springs, the upper ones light and flexible and the lower ones stiffer and more rigid.

It is true that the beds in sleeping-cars always have a shallow mattress of varying degrees of softness and hardness on top of the seat and back cushions. This is nearly always insufficient to prevent the protrusion of the bones of the passenger—especially when they have been hardened by the chilling effects of some scores of winters—to the seat cushion below.

It may be added that if the seat cushions had more elasticity, those in the back could also be made more unyielding, which would make the latter more comfortable by day and also by night.

Both the Pullman and the Wagner companies have been liberal in the expenditure of money for the gratification of the public's taste for what the ladies call "elegant" upholstery and cabinet work, until the magnificence of some of their cars has become oppressive. In view of their skill and liberality in other directions, it is a matter of some surprise that they have not provided that essential for sound sleep—comfortable beds.

Another subject of general complaint is the heating of cars. With some of the systems of heating with steam from the locomotive—perhaps with all—the lower and at times the upper berths of sleeping-cars become chambers of torture. Passengers are compelled to sleep over hot steam-pipes whose temperature they cannot control, and which, apparently, is not controlled by any one else. Added to this is often impure air due to inadequate ventilation. There is either no adequate means of regulating the steam-heating apparatus and the ventilation of the cars, or the attendants do not know how or are indifferent about using the means of regulation. Of late years we have heard a great deal about color-blindness. Apparently many of the attendants of sleeping and other cars are blind in their noses, and have little or no sense of temperature. They are also very ignorant usually about the properties and quality of air. It is almost impossible to make an ordinary sleeping-car porter—or, for that matter, an average passenger—comprehend that air which is cold may also be impure. Hotness and coldness are the only two properties which they seem to think air can have. Even in the matter of temperature their senses are usually very obtuse. They do not seem able to discern any difference less than from 40° to 50°. They seldom discover that a car is getting too cold until its temperature gets down to about 40°, nor do they find out that it is too warm until it reaches about 90°. As for impurities in air, most of them do not seem to comprehend that there is any such thing.

Inasmuch as the comfort and to a considerable extent the health of passengers in sleeping-cars is in charge of their attendants, it would seem worth while that those in control should learn something of the capacity of their employés for their duties. It would be interesting and curious, and probably advantageous, to the traveling public if applicants fo employment as porters and conductors of sleeping and drawing-room cars and brakemen of passenger trains were subjected to a sort of car-service examination. Among the questions which might be asked would be such as the following:

1. Can you smell?

(Then the candidate's sense of smell should be tested by trying whether he could distinguish the odor of well-known substances, as camphor, turpentine, kerosene, whiskey, peppermint, Limburger cheese, etc., in weak solutions.)

2. Can you feel the difference between warm and cold objects?

(A test of the sense of feeling should then follow by having the applicant put his hand in basins of water of different temperatures.)

3. Do you know what a thermometer is?
4. What is it for, and what does it show?
5. How warm should a room or a car be, in winter, to be comfortable?
6. At what temperature does a car become too warm, and at what too cold?
7. If a car was too cold in winter, what would you do?
8. If it was too warm, what should be done?
9. If the air smells bad, how can it be made pure?
10. If you opened all the ventilators and the car then became too cold, what would you do?
11. If you closed them all and it then began to smell bad, what ought to be done?

(If in reply to the two last questions the examinee should not suggest that *some* and not *all* of the ventilators might be opened or closed, he should be remanded for further instructions. It never seems to occur to porters or brakemen that *some* of the ventilators in a car may be either opened or closed. They either open *all* of them or shut *all.*)

12. Is impure or foul air always warm?
13. Is cold air ever foul?
14. Does cold air ever smell bad?
15. To keep the air in a car pure, what must be done?
16. Do you use tobacco or chewing-gum?
17. How often do you take a bath?

Other questions might, of course, be asked to advantage, and the catechism of car service could be much extended. The above interrogations are merely suggestions. Such an

examination would certainly have the effect of stimulating candidates to inform themselves about subjects which their duties seem to demand they should have some knowledge of.

Another deficiency in sleeping-cars is the want of some suitable place for locking up one's valuables. Every one feels more or less nervous about going to sleep in a car with a valuable watch or jewelry and a considerable amount of money or maybe important papers or documents on his person.

It is curious to notice, too, what a strong hold on all men habit has. We go in certain beaten paths which are well worn, and only very strong influences seem to divert most people from them. Mere deductive reasoning seldom seems to be sufficient to divert people from the road which is trodden into ways of rationality. The special instance which has called forth these remarks is the height of the arm-rests of car seats. With the old method of reversing the backs of seats it was essential to place the pivots of the reversing arms about 8 or 9 in. above the seats. This required that the arm-rests should be from 10 to 12 in. higher than the seat. Consequently to rest the arm on it, it was necessary to "hunch" up the shoulder into a most uncomfortable position. As the demands of the mechanism for reversing seat backs required this height, it had to be submitted to. When drawing-room car chairs were introduced, it was soon observed that their comfort was materially improved by lowering the arm-rests, and they are now seldom made more than 6 or 8 in. high above the seat. Notwithstanding the fact that the improved mechanisms for reversing seats no longer require so great a height of arm-rest, nevertheless some car-builders, from the mere force of precedents, insist on having arm-rests made so high that they are uncomfortable. What is still more curious is that in some of the Wagner sleeping cars, in which the backs of the seats are not reversible, the arm-rests at both ends of the seats are made 11½ in. high. In both the Pullman and the Wagner cars the arm-rests at the outside ends of the seats are very uncomfortable. Not only are they too high, but they project inward and take up room lengthwise of the seat. On the Chicago, Burlington & Quincy Railroad we had the privilege of traveling in some cars equipped with ordinary seats and also others with reclining seats. These had the improved window recesses below the windows. Not only are the arm-rests at each end the right height for comfort, but they give room enough laterally for the arms of passengers occupying the seats. If a person sits close up against the side of a car his or her arm occupies from 3½ to 4½ in. of space. As the window recess referred to gives room enough for a person's arm, the practical effect is to lengthen the available sitting room in the seat from 3½ to 4½ in. In sleeping and other cars the window recesses not only have this advantage, but they provide receptacles for books, packages, etc.

The habit of smoking has now become so common that the popular mind has fallen into an attitude in which it is no longer conscious that non-smokers have rights which ought to be respected. Consequently we find that many modern sleeping-cars are provided with smoking apartments, to which perhaps no valid objection can be made if they are properly arranged. In the Wagner car, in which it was recently our lot to make a journey, the entrance to the smoking-room led almost directly into the main apartment of the car. Consequently the odor of more or less vile tobacco smoke at times pervaded the whole car. If the entrance to the smoking-room is toward the nearest end of the car, then, if that end is in front, the air is blown into the smoking-room and out the ventilators. If the smoking-room is at the rear end, the air which escapes from its door is drawn out of the back door of the car.

Another query many travelers must be disposed to make, Why are the wash-basins in sleeping cars made so low? When a car is running at considerable speed, especially on a crooked or rough road, it is almost impossible to preserve one's equilibrium while engaged in the morning ceremonial of washing one's face. When obliged to assume a position analogous to that of a partially opened three-bladed jack-knife, one cannot estimate the position of his center of gravity with the requisite celerity to retain his balance.

Although this report of an amateur inspector of sleeping-cars has exceeded its allowable limit of length, time and space will be taken for one more growl. The car in which it was his lot to travel from Chicago to New York was heated by steam from the engine. What the particular system of heating was is not known by the writer. It had one defect, however, which was serious. When steam was turned on the water-hammer was terrific. We use the latter word advisedly. The sound was as though a collision had occurred, and an engine or car had run into the one in which the hammering occurred. If the annoyance was remediable by the porter or conductor, they did not know how to apply or employ the remedy, which may perhaps be another reason for establishing some kind of civil-service examination for porters and conductors. Turning on steam in the car referred to would certainly make sleep impossible to all excepting the most confirmed and persistent snorers.

Our fault-finding has occupied so much of the space in this report that there is not room for more than a very little commendation. There are some things in which the last few years have brought great improvements in travel. Many of us can remember dismal hours spent in cars between nightfall and bedtime, when reading was impossible and the passing landscape was viewless, and the light inside the cars was insufficient to read by. The train which has been the subject of some animadversion was lit by the Pintsch gas system, and reading of good print was comfortable almost anywhere in the car.

Then, too, the leisurely feeding in a modern dining car is a great improvement over the meals hastily and nervously eaten at a wayside restaurant. The train service has generally improved, notwithstanding some defects which have been pointed out. The speed of trains has been increased and cars are generally more comfortable, so that one may now regard a journey as a period of rest and repose instead of one of weariness.

NEW PUBLICATIONS.

WATER TOWER, PUMPING AND POWER STATION DESIGNS. *The Engineering Record's Prize Designs, Suggestive for Water Towers, Pumping and Power Stations.* (72 pp., 10½ × 13½ in.) New York; *The Engineering Record.*

In 1890 the *Engineering Record* instituted an architectural competition and offered prizes amounting to $250 for the best designs for a water tower or pumping station. The purpose of the competition was to call out designs of a more or less artistic character, with a view to beautifying such buildings, which generally occupy prominent locations, and therefore may be either an offense or a pleasure to those who must look at them. One hundred and twelve designs were received, 56

of each structure. Prizes were awarded to four of these, and 13 received honorable mention. Engravings of these 17 selected designs are published in the volume before us.

The study of an architect's designs of purely engineering structures is always interesting, sometimes amusing, and at others infuriating. Many of them find it very difficult to act in accordance with Ruskin's maxim, to ornament their construction and not construct their ornament.

A criticism of the designs would, however, lead further than we are now prepared to go. Some of them indicate what many observant people have noticed before, that there are architects who adopt and pile useless ornament on their structures with apparently the same kind of wild and uncontrollable passion that some women manifest in their dress. Happily the consequences of this kind of lavishness is not so costly in the mere making of designs as it is in carrying them out. The plans of many of the water towers which are illustrated in the volume before us are very picturesque, and will at any rate be suggestive to those who have occasion to decide about building such structures.

The suggestions for pumping, power and electric-light stations will also aid those who have occasion to build such structures. The "treatment"—we believe that is the proper artistic term—of the chimneys in these designs is interesting. As such structures form very prominent objects, it would seem as though, if any parts of a building should be ornamented, it would be these but in the designs before us while a great deal of ornament is lavished on the buildings for the engines and boilers, there is very little on the chimneys or smoke-stacks. In the first design the chimney is an absolutely plain square structure, with a little taper toward the top. The second one is apparently plain, tapered and round, with a little moulding near the top, which is sketched in very indistinctly. The third is similar to the second. The fourth is also round, with a little moulding at the top, but with bands of differently colored stone or brick from its base all the way up. The sixth is square and plain, but with colored bands extending from a little above half its height to the top. The seventh is round and plain, with a flare at the top and very indefinitely drawn. The eighth is square at the base and octagonal above, with ornament on the corners of the octagon, and somewhat elaborate mouldings extending for some distance below the top. It is sketched merely in outline, but looks as though it might make a very simple and graceful structure. The ninth is square and perfectly plain, excepting a cap, which is slightly rounded inward or toward the center of the flue. The tenth is square, with plain mouldings near the base and more elaborate ones at the top. Between these points it is entirely plain. The eleventh is round and perfectly plain, with the exception of colored bands and a little moulding at the top. The twelfth is round and plain, with heavy ornamentation at the top. The thirteenth is square, perfectly plain, with the exception of a very slight projection around the top. The fourteenth is round and plain up to near the summit, where there are some heavy decorations. The fifteenth is square, with stones or bricks at the corners of different color from those between. The top has an ornament which reminds one of Downing's style of architecture, which overspread the country 30 or 40 years ago. The sixteenth does not show a chimney. The seventeenth shows a chimney with a square base and octagonal above, with somewhat heavy ornament near the top.

Nearly all the buildings connected with these chimneys are elaborately decorated. Now it is submitted that, in view of the prominence of the chimneys, that they have been neglected. What is wanted, Messrs. Architects, is new "treatment" and new "motives" for smoke-stacks. Ancient architecture gives us no examples of such structures, and the imaginations of our modern builders seem to have been singularly barren in suggestions. It is true that there is something prosaic about *chimneys*, which fact seems to have led our architectural friends to neglect them. It would not sound very fine to speak of a Renaissance chimney or a Gothic smoke-stack. Nevertheless, under the magic of modern science and civilization these structures have become veritable pillars of cloud by day and of fire by night.

One defect in nearly all the designs for pumping, power or electric-light stations is a lack of window room and light. Any building devoted to mechanical work or the shelter of machinery should have all the light in it possible. Even if little or no manual labor is carried on there, the care, supervision and inspection of machinery requires an abundance of light, and barring the glare of sunshine, there cannot be too much. Therefore all such buildings should have as little wall and as much window area as possible. More light is needed in a power house to run a steam-engine than is required in a church to say one's prayers.

The book before us is well printed, and the engravings, although made from rather sketchy drawings, serve their purpose very well.

BUILDINGS AND STRUCTURES OF AMERICAN RAILROADS. *A Reference Book for Railroad Managers, Superintendents, Master Mechanics, Engineers, Architects and Students.* By Walter G. Berg, C.E., Principal Assistant Engineer, Lehigh Valley Railroad. New York; John Wiley & Sons. Illustrated, 500 pages; price, $7.50.

One defect of modern engineering literature is its fragmentary and scattered nature, which is due to the large number of technical publications in existence, and also to the number of technical societies which are continually calling on the engineer for contributions to their proceedings. It results from this that a search for information on a given subject requires a hunt through files of all sorts, and sometimes valuable material is passed over or missed because it is not accessible to the searcher. The author who collects and edits information of this kind on a given subject and puts it in a form where it is ready for use does a service to the profession, even if his work does not extend beyond the compilation.

Mr. Berg, however, has done much more than this. He has collected and presented in excellent shape much that had already been published in this scattered way; but he has also added much original matter in the way of comment and criticism, and has also given many designs for buildings on different railroads which have not heretofore been published. He has evidently done some careful work, and has taken pains to bring his accounts up to the latest date; a matter of considerable difficulty in an age of constant change.

The subjects treated include buildings of every class: Stations—including a number of important terminal stations—shops, section houses, water stations, coaling platforms and a number of others, including some which are very useful after their kind, but do not often find mention, such as sand-drying and storing houses, oil-mixing houses and others. The variety of structures needed on a railroad can hardly be appreciated by those who have not had experience in building or using them; but some idea can be obtained from this book.

The text is generally well written, not at all diffuse but rather condensed, and many of the criticisms are pointed and well taken. It is very fully illustrated, nearly 700 drawings and diagrams being given in the work.

BOOKS RECEIVED.

A Treatise on Gear Wheels. Sixth edition. By George B. Grant. Lexington, Mass.; published by the Author.

Tenth Annual Report of the Board of Railroad Commissioners of Kansas for the Year ending December 1, 1892. Topeka, 1892.

Twenty-fourth Annual Report of the Board of Railroad Commissioners of the Commonwealth of Massachusetts: January, 1893. Boston, 1893.

Annual Report of the State Board of Arbitration of the Commonwealth of Massachusetts for the Year 1892. Boston, 1893.

Journal of the United States Artillery: January, 1893. Fort Monroe, Va.; published by authority of the Staff of the Artillery School.

Journal of the Military Service Institution: March, 1893. Governor's Island, New York Harbor.

Journal of the American Society of Naval Engineers: February, 1893. Washington, D. C.

Professional Papers of the Corps of Royal Engineers. Edited by Captain W. A. Gale, N.E. Chatham.

Infantry Drill Regulations, United States Army. With interpretations of 250 Pars., by the Recorder of the Tactical Board. New York; *Army and Navy Journal.*

TRADE CATALOGUES.

THE DEITZ DRAWBAR COMPANIES, Denver, Col. (8 pp., $3\frac{1}{2} \times 6$ in.)

This little publication illustrates and describes two forms of couplers, one of the link and pin type and the other of the M. C. B. type. Two companies have apparently been organized for the manufacture of the two types of couplers, which are illustrated and described in the catalogue before us.

HEISLER'S GEARED LOCOMOTIVES. *Charles L. Heisler, M.E.* Philadelphia.

In this diminutive pamphlet (12 pp., $3\frac{1}{2} \times 6$ in.) the author describes a system of locomotives of which he is the inventor. The chief peculiarities are that the locomotives are supported on two or three trucks which are driven by gearing and longitudinal shafts. The construction could not, however, be explained so as to be understood without the aid of engravings.

MODERN ELECTRIC, STEAM AND HAND CRANES, *for Foundries and Machine Shops, Iron and Steel Works, Electric Power Stations, etc.* Built by Pawling & Harnischfeger, Milwaukee, Wis. (8 pp., $6 \times 9\frac{1}{2}$ in.)

In this publication a swing and several forms of travelling cranes are illustrated and described. These may be driven by hand, electric, or steam power. The engravings and descriptions are clear and satisfactory to the reader. The catalogue is an indication of the extent to which this class of machinery has of late years been introduced into this country.

The above firm also make lathes, drilling and boring tools, and special machinery.

CONSOLIDATED CAR-HEATING COMPANY. *Part IX. Improved Locomotive and Tender Equipment*, Albany, N. Y. (12 pp., $7 \times 10\frac{1}{2}$ in.)

This is one of a series of parts of a catalogue issued by this Company to describe their steam-heating apparatus. Part IX. contains first two large folded plates, showing the positions in which the Sewall steam couplers should be located on cars and locomotives. These are followed by a description of the locomotive equipment for steam heating, and also of the method of heating fruit, freight, and baggage cars.

THE MCSHERRY MANUFACTURING COMPANY, *Manufacturers of the Maxon Patent Lever, Screw and Ratchet Lifting Jacks*, Dayton, O. (30 pp., $6 \times 8\frac{1}{2}$ in.)

Not much can be said of this catalogue, excepting that it illustrates very clearly the different kinds of railroad and wagon lever and screw jacks made by the Company. The engravings are very good and the descriptions clear. One feature of the arrangement is very good. A full page is devoted to the engravings of most of the jacks, and on the opposite page illustrations are given of the different parts or "repairs" of the implement shown which are all suitably numbered. Neither the paper nor the printing is of a "fancy" character, and the impression produced by the catalogue is that there is no nonsense about it or about the implements it describes.

ALMY WATER-TUBE BOILER COMPANY, *Manufacturers of Almy's Patent Sectional Water Tube Boiler for Marine and Stationary Work*, Providence, R. I. (Third edition, 16 pp., $5\frac{3}{4} \times 8$ in.)

The title-page of this pamphlet gives a perspective external view of one of the boilers, which is followed on the next page by an introduction. This is succeeded by a description of the construction of the boiler. After this are various outside and sectional views. The description, it is thought, would have been a great deal clearer if it had referred directly by letters of reference to some of the sectional views, as an explanation is always much easier understood if accompanied with an object lesson in the form of a picture.

Engravings and tables of dimensions of different sizes of boilers are given, and after them a statement of the advantages claimed, and the volume ends with a comparative statement of the performance of one of these boilers on the steamer *Queen City*, and a list of the boilers furnished to different parties.

DESCRIPTIVE CATALOGUE OF THE FOSTER STEAM-PRESSURE REGULATORS, PUMP GOVERNORS, AND REDUCING-VALVES; *also of the McDowell Inside Safety Check-Valve for Locomotive and Marine Boilers.* Foster Engineering Company, 21 and 23 Prospect Street, Newark, N. J. (32 pp., $6 \times 9\frac{1}{2}$ in.)

This is a well-printed and well-illustrated publication of its class. The frontispiece is a "half-tone" engraving showing the interior of the assembling and testing-room of the Company. Another similar engraving farther on in the pamphlet shows the testing apparatus. The publication opens with a statement of what the Company makes, which includes the Foster pressure regulator, a combined steam-pressure regulator and pump governor, a regulator operated by a piston and lever, a valve for regulating the steam heating of trains, another for steamships, an "all round" valve for melting and manufacturing plants, and the McDowell inside safety check-valve for locomotive and marine boilers. All of these are well described by excellent wood-engravings and well-written explanations of their construction and operation. These are succeeded by directions for setting and operating the valves and "testimonials" of their efficiency. It is an excellent example of this kind of literature, although we are inclined to think that if the commendation in it of the articles made by this Company was a little less vehement it would be more convincing, but probably the author thought, as many people do, that "he that bloweth not his own horn, verily it will not be blown."

THE LINK BELT MACHINERY COMPANY, of Chicago, Ill., have sent us half a dozen publications illustrating different kinds of machinery which they manufacture. The one on

special mining machinery (4 pp., 6 × 8 in.) announces that they have associated with them Mr. Howard McLean as Superintendent and Mr. Thomas R. Griffith as Engineer of Construction, and that they are prepared to supply special mining machinery, which is intelligently designed and thoroughly well made, including breaker rolls, coal screens, mine ventilating fans, and tail and endless rope haulage.

Another of the publications (16 pp., 6 × 8½ in.) is on MANILLA ROPE POWER TRANSMISSION as applied by this Company. Its frontispiece is a very good wood-engraving showing a view of their works, and the beginning is on rope driving and its advantages. On the fifth page is a half-tone illustration showing the driving-gear in the dynamo-room of the Virginia Hotel in Chicago. The following page has a similar illustration of the dynamo drives in the Chamber of Commerce Building in Chicago. The following seven pages contain engravings made from pen-and-ink drawings, which, as works of art, cannot be commended very highly, but they nevertheless answer their purpose of showing the construction and arrangement of various factory "drives" or "rope transmissions" which the Company have put up in various localities. These engravings also have very terse and clear-printed descriptions appended. Two pages of testimonials and two more of general advertisements conclude the pamphlet.

The third of the series is a four-page folder giving an engraving and description of a system of conveyers for handling corn and husks. It is added that they have supplied similar machinery for elevating and conveying cobs, pea-pods, tomato slops, green vegetables, fruits, fish, meats, cans, boxes, etc.

The fourth publication of the series is an eight-page folder describing and illustrating elevating and conveying machinery, and gives very good engravings and descriptions of elevators for handling barrels, baled hay, boxes, ashes, and other materials.

The fifth of the series is a single leaf giving an engraving of a brick-dust elevator.

The sixth illustrates and describes a locomotive coaling station erected at New Buffalo, Mich., on the Chicago & West Michigan Railroad.

The last publication is a pamphlet of 24 pages, 5½ × 8 in., and describes special machinery for use in saw-mills, planing-mills, and wood-working establishments. All of these circulars are well printed on coated paper, and the engravings, with the exception noted, are of the best. In these days of standards one wonders though that this Company did not make all their catalogues of uniform size. Some of them would have gained in clearness, too, if fancy-colored ink had been ignored and good black ink only had been used.

NOTES AND NEWS.

Advertisements Prohibited.—The following order emanated from the Maine Central Headquarters last week, addressed to all station agents and section foremen along the line: "You will not allow any parties to paint signs or place posters or advertisements on walls or fences belonging to this company; nor on any objects upon land belonging to this company or within our right of way. It is the intention of this company to have its station grounds and right of way present a neat and attractive appearance, and your co-operation in securing this is desired and expected."—*Portland (Me.) Argus.*

A remarkable artesian well-boring has just been completed at Willoughby, in Lincolnshire. Owing to an inadequate water-supply for the locomotives running on the Sutton & Willoughby Railway, the company decided to bore. At a depth of 245 ft. from the surface the workmen struck upon a bed of iron-stone, which took them a considerable time to penetrate, but beneath this rock a magnificent spring was met with. For some time the water threw out tons of blue sand, but it eventually cleared, and it now flows over a 2¼ in. tube 30 ft. above the ground, at the rate of 4,619 galls. per hour, or 1¼ galls. per second. The spring is said to be the strongest yet obtained in Lincolnshire.—*Engineer.*

The Efficiency of Boilers.—In a recent discussion by the Engineers' Club, of Philadelphia, U. S. A., on this subject, Mr. Strong stated that the difficulty in the way of introducing producer plants and gas engines is the first cost and difficulty of starting the engines; but the latter difficulty will probably soon be overcome, and the gas-engine will then supersede the steam-engine in many cases. An engine has been designed which is to make a horse power on 13 lbs. of water, to carry 180 lbs. pressure in the boiler, allowing the gas to escape at 250°, and evaporating 12 lbs. of water to a pound of coal. Many think that the locomotive is an uneconomical steam-engine, but it really compares very favorably with the general run of automatic engines to be found. A few years ago a test was made on the Lehigh Valley Railroad, under favorable circumstances, on a boiler having 1,848 sq. ft. of heating surface; 900 H. P. was developed, 8 lbs. of water being obtained per pound of coal; and in another boiler which was tested, 28 lbs. of water to the H. P. was used, while in the one first spoken of only 20 lbs. was used. The Boston sewage pumping plant is getting about 12 lbs. of water per pound of coal, using two sets of boilers. In the locomotive we get 9 lbs. of water while we were making 2 H. P. for each 2 sq. ft. of grate. As opposed to this, Mr. Spangler said that he doubted very much whether the boiler had been made which would average 12 lbs. of water per pound of coal.

The Largest Express Engine in the World.—A few years ago one of the Webb three-cylinder compound locomotives was sent over from this country to America for trial; however, the results of practical and perfectly fair tests is that the English engine has been very badly beaten. This fact appears to have induced Mr. F. C. Winby to design an English engine to send to the Chicago Exhibition, and it is just completed at the works of Messrs. R. & W. Hawthorn, of Newcastle, and within the past few days a very large number of engineers have accepted the invitation to inspect the new engine. This vast locomotive, named the *James Toleman*, runs upon a four-wheeled leading bogie, and two pairs of independent driving-wheels of 7 ft. 6 in. diameter, and it has four high-pressure cylinders. Two cylinders placed inside under the smoke-box are 17 × 22; they actuate the first pair of driving-wheels. Two outside cylinders are placed behind the bogie wheels; they are 16½ × 24, and work the second or trailing pair of driving-wheels. The total tractive force exerted by the four cylinders upon the four driving-wheels is therefore 143 lbs. for each pound of effective pressure. The boiler works at a pressure of 175 lbs., but it is constructed to carry 200 lbs., if necessary. The boiler is of oval section, in order that it may be placed between the tops of the driving-wheels. Number of tubes, 189; diameter of tubes, 2⅜ in.; length of tubes, 16 ft.; heating surface of tubes, 1,880 sq. ft.; heating surface of fire-box, 136 sq. ft.; total heating surface, 2,018 sq. ft.; area of fire-grate, 28 sq. ft.; weight of engine in working order, 60 tons; and the tender, when loaded, is fully 45 tons, so that the engine and tender complete weigh about 105 tons. Mr. Winby has therefore designed, and Messrs. Hawthorn have constructed, the largest locomotive ever seen in England; and the fact that the engine uses high-pressure steam in all the cylinders is a most important feature in its favor. Its construction has been watched both in this country and in America with very great interest.—*Communicated to the Leicester (England) Daily Mercury.*

FOREIGN MARINE NOTES.

Viking Ship.—The Viking ship, intended for the Chicago World's Fair, was recently launched in Christiania, Norway, amid great enthusiasm.

The old Viking ship of Gogstod was discovered about twelve years ago near the village of Sandefjord, where it had lain buried for a thousand years or more.

The vessel launched is a true copy of the original. It will be manned by Norwegian sailors and sailed across to Chicago.

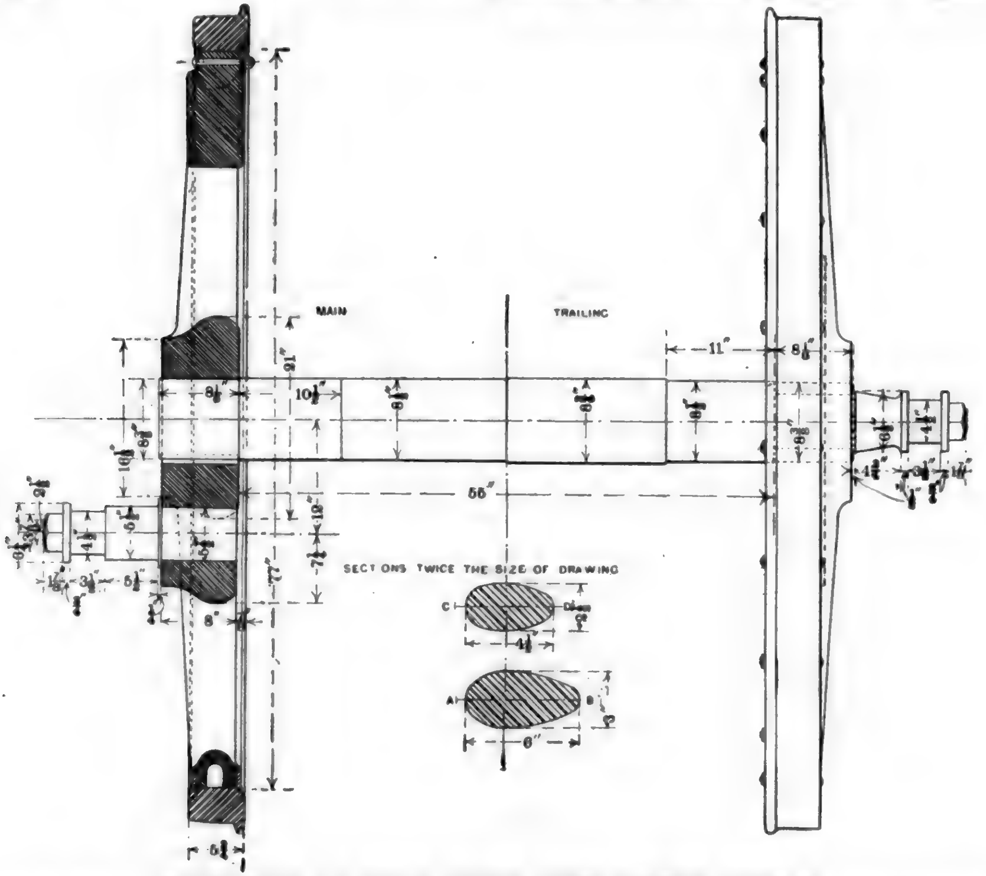
A Curious Transformation of Brass.—A curious incident has been noticed in connection with the brass condenser tubes of a foreign cruiser. The pipes, after being in use for rather more than twelve months, were found to have experienced a peculiar change. In many places the metal has been, it appears, converted into almost pure copper of a spongy texture, the zinc of the alloy having completely disappeared. An investigation which was made showed the probable cause of the failure to have been an electrolytic action between the tin lining of the tubes and the brass, the sea-water circulating through the condenser forming the electrolyte. Had the tin coating remained perfect, doubtless no corrosion would have

resulted, but the mud and grit conveyed in suspension through the condenser carried away the tin coating in spots, and it was at these points that the transformation of the metal occurred. It is concluded that if the pipes had not been tinned at all, they would have remained intact.—*Iron.*

Foreign Whalebacks for American Trade.—The American Steel Barge Company has contracted to build two vessels at or quite near Liverpool, Eng., on the general plan of Captain Alexander McDougall's whalebacks. One will be a steamer and the other a tow barge or consort, and as such they will be the first vessels of the kind to cross the Atlantic Ocean. They will be put into the iron ore trade between Cuba and Philadelphia, and will be ready for their first cargoes in July. They will be duplicates of the *James B. Colgate*, only 2 ft. deeper and with more power, the engines being the same style and size as those in the big *Pathfinder* launched last year.

with wood 3½ in. thick, to the height of about 1 ft. above the water-line. A protective deck of varying thickness extends throughout the whole length of the ship. Her circular conning tower, situated on the forecastle, is formed of 3-in. steel armor plates, the top or covering plate being 1 in. in thickness; her torpedo-director tower, situated near the stern, is wholly built of ½-in. steel plates. Like her sister vessels, she is to be fitted with twin vertical triple-expansion engines, the diameters of the cylinders being, high-pressure, 49 in.; low-pressure, 74 in. The engines are to make 140 revolutions a minute, and to develop, under forced draft, during a continuous sea trial of four hours, 9,000 H. P., and with ordinary draft 7,000 H. P. The estimated cost of the hull is $70,000, and of the engines and auxiliary machinery, $250,000.

Steam Hammer on Board Ship.—Considering the exceptionally solid foundations that are required for steam hammers, this class of tool would seem to be altogether out of place on



DRIVING WHEELS AND AXLE OF AMERICAN EXPRESS PASSENGER LOCOMOTIVE

The vessels will sail under the British flag and will carry short pole spars similar to those employed on the *J. L. Colby*. These vessels will be the forerunners of an extensive fleet to be built abroad at various seaports before the close of 1894. The combined carrying capacity of the two vessels will be 9,000 tons.

The "Cambrian."—On Monday, January 30, there was launched at Pembroke Dockyard Her Majesty's ship *Cambrian*. The displacement of the *Cambrian* when fully equipped and ready for sea will be 4,360 tons. She is 320 ft. long, her extreme breadth is 49 ft. 6 in., and her depth of hold, 15 ft. 6 in. When completed and ready for commission, with ammunitions, stores and all equipments on board, her mean draft will be 19 ft. Her upper deck will be 14 ft. 3 in., and the center of her midship guns 18 ft. above the water-line. The hull of the vessel, which is built of ⅝-in. steel plates, is sheathed

shipboard; but Messrs. B. & S. Massey, of Openshaw, have recently supplied to H. M. Dockyard, Devonport, one of their steam hammers, which is to be fixed on board H. M. S. *Defense*, which has been converted into a floating factory. To meet the requirements of the peculiar position in which the hammer is to be placed, special construction has, of course, been necessary. The hammer is of the overhanging form, with two standards, in which are planed guides, and between these the tup has a falling weight of 3 cwt.—without taking into consideration the pressure of the top steam—and the maximum stroke is 17 in., the diameter of the cylinder being 7½ in. The hammer is fitted with combined self-acting and hand-worked valve-gear, and will work very quickly or slowly, as desired, the change either as to speed or force of blow being effected instantly. In the special arrangement of the hammer, the separate anvil-block and base are made in one massive casting of great weight, so as to cause as little vibration as

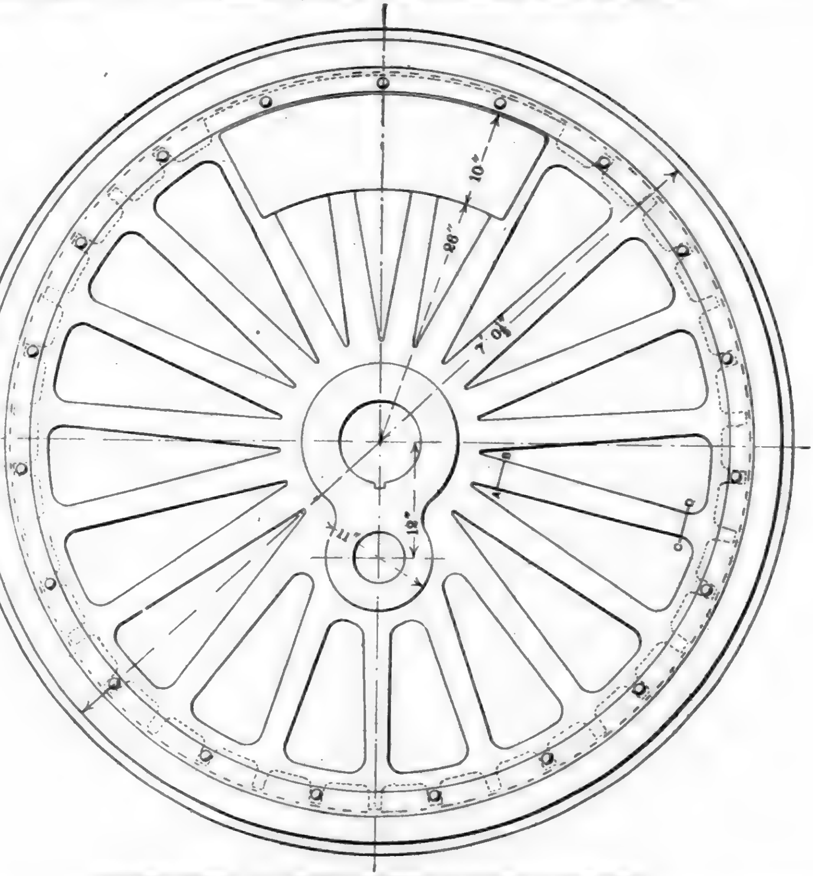
possible in the surrounding parts of the ship, and a 6-in. armor plate is fixed underneath in a vertical position, as a foundation for the anvil-block. This is perhaps the first time that it has ever been attempted to erect a steam hammer except on land, and no doubt the one supplied by Messrs. Massey will prove a very useful tool for repairs on board the floating factory at Devonport.—*English Mechanic.*

The "De Julio"—The Argentine Navy enjoys the distinction of possessing the fastest cruiser in the world. This vessel has recently been built in the English shipyard of Sir W. G. Armstrong, Mitchell & Company, and the steam trials conclusively show that she possesses a speed which under natural drafts has only been equalled by the fastest of the Atlantic liners in the most favorable conditions of wind and sea. She is known as the 9 *De Julio*, and is 350 ft. long, 44 ft. broad, and has a displacement of 3,500 tons.

The propelling machinery consists of two sets of four-cylinder triple-expansion engines, the two low-pressure cylinders in each set having a diameter of 66 in., the intermediate cylinder 60 in., and the high pressure cylinder a diameter of 40 in., the length of the stroke being 30 in. Steam is generated in eight single-ended return tube boilers, situated in two separate water-tight compartments, each compartment containing four boilers. Each set of engines is also confined in a water-tight compartment. In a series of runs the speeds ranged from 11¾ knots up to 22.74 knots, the latter mean speed being obtained under forced draft. The six hours' run was made under natural drafts, in accordance with the conditions laid down by the British Admiralty. During this period of steaming four runs were taken on the measured mile, and the speeds and revolutions were accurately taken by stop watches and the mechanical counters in the engine-rooms. The speeds and revolutions were also recorded by an electric apparatus in the chart-house of the ship, which noted on a traveling band of paper each revolution of each engine, each half second of time, and the beginning and ending of each run for the mile. The mean speed of these four runs was 22.028 knots, corresponding to the mean revolutions of engines of 149.1 per minute. The average revolutions of the engines during the six hours' run were 148.3 per minute. The vessel is armed entirely with quick-firing guns of the latest and most approved pattern. She carries four 6-in., eight 4.7-in., twelve 3-in., and twelve 1-in. quick-firing guns. She also carries five 18 in. torpedo-tubes.

AMERICAN AND ENGLISH LOCOMOTIVES.

On pages 164 to 169 we give this month engravings of the driving-wheels, axles, crank-pins, and driving-axle boxes of Mr. Buchanan's express passenger locomotive on the New York Central Railroad, and the same parts of Mr. Adams's engine for the London & South Western road.



DRIVING WHEEL OF AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

The following are the specifications of these parts for the American engine :

DRIVING-WHEELS.

Four in number. About 84 in. diameter. Centers cast of the best charcoal iron and turned to 77 in. diameter to receive the tires.

TIRES.

Of steel 3¼ in. thick ; both pairs flanged 5¾ in. wide, and held to center by retaining rings.

AXLES.

Of hammered iron, with journals 8½ in. diameter by 11½ in. long.

DRIVING-AXLE BOXES.

Of Ajax metal with large oil-cellars.

SPRINGS.

Made of the best cast steel tempered in oil. Secured to a system of equalizing beams to insure the engine riding in the best possible manner. The springs to be hung underneath the driving-axle boxes.

CRANK-PINS.

Of hammered iron.

Specification of English Express Locomotive.

DRIVING AND TRAILING-WHEEL CENTERS.

The wheel centers to be of good sound cast steel, of approved make, free from honeycomb and other defects. One wheel center out of 40 is to be tested to destruction under the following conditions:

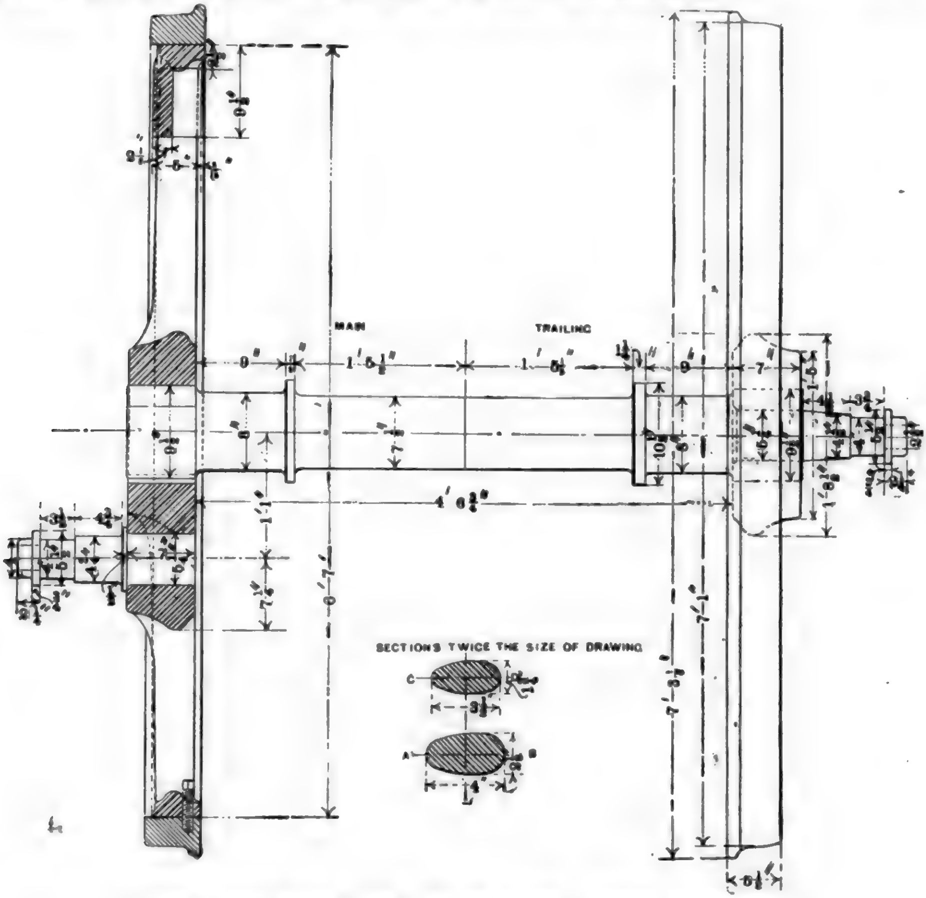
The wheel center is to be raised in a running position and allowed to fall upon a solid foundation from the following heights: 10 ft., 15 ft., 20 ft., 25 ft., 30 ft.

Should any wheel center break at the two lower heights—viz., 10 ft. or 15 ft., and show defects on hard material, the Railway Company's Locomotive Superintendent or his Inspector shall have the power to reject the whole. The wheels to be inspected on the premises of the maker.

Tensile test pieces are to be taken from the wheel center to give a breaking strain of not less than 28 tons per square inch, with an elongation of not less than 20 per cent. in 2 in.

Each wheel center is also to be tested, by being allowed to fall in a running position a distance of 4 ft. 6 in. on to a wooden block, without showing any signs of defect.

All the wheel centers must be bored, and turned, and have keyways cut strictly to template so that they shall be exactly alike, and each wheel must be forced on the axle before the tire is shrunk on by a hydraulic pressure of not less than 80 tons. The rims must be correctly turned to gauge to receive the tires, and the whole wheel trimmed up so that the surfaces and lines are all fair and true. The wheel centers are to be turned to a diameter of 6 ft. 7 in., the rims are to be 4½ in. broad, 2¾ in. thick at center, to have 22 spokes, 2¼ in. thick at the boss, and 4 in. deep, and at the rims 1¾ in. thick by 3¼ in. deep. The bosses are to be bored out parallel to a diameter of 9¼ in., and are to be 1 ft. 5 in. diameter. The cranks for the coupling-rods are to be cast solid with the bosses, 13 in. centers, and bored out parallel to a diameter of 5¼ in. to fit the coupling-rod crank-pins. The crank-pin holes are to be bored in a suitable quartering machine. The balance weights to be cast solid and to be different for the driving and trailing-wheels. Care to be taken that each wheel is cast with its proper balance weight. Generally the wheel centers must be as shown on the drawing.



DRIVING WHEELS AND AXLE OF ENGLISH EXPRESS PASSENGER LOCOMOTIVE.

TIRES.

The tires are to be of the best cast steel, manufactured by Vickers & Company, and are to be tested at the works of the maker in the following way:

Each tire is to be guaranteed to stand, without fracture, the repeated falling of a 1-ton monkey from a clear height, first blow, 10 ft.; second, 15 ft.; third, 20 ft.; fourth, 25 ft.; fifth, 30 ft., and so on. Any tire which cracks or breaks before it has deflected one-sixth of its external diameter is to be rejected.

Test pieces are to be machined cold out of the tire, without reheating the steel or treating in any way beyond cold machining, for tensile test. The minimum tensile strength to be 44 tons per square inch, and to have an extension of not less

than 15 per cent. in 2 in. A suitable and sufficiently large piece is to be sent to Nine Elms for testing in a similar manner.

The contractor shall require the maker to provide at his own expense one additional tire for each 50 ordered, to be selected from the bulk by this Company's Locomotive Superintendent or his Inspector, and to be tested in his presence by the maker in the manner before described.

In the event of one tire cracking or breaking, or failing to stand the test, the Company to have the power to reject the whole.

The number of the charge is to be stamped on each tire, and in the event of there being more than one charge in every 50 tires, a tire shall be selected from each charge and tested.

The maker's name and date of manufacture is to be stamped on each tire.

All the tires are to be 3 in. thick, of the form shown on drawing, and to be secured to the wheels with a lip and steel set screws $1\frac{1}{4}$ in. diameter, 11 threads per inch. Each tire to be bored to gauge before being shrunk on the wheel center. Each tire to be accurately turned so that the diameters and thickness shall be exactly similar.

AXLES.

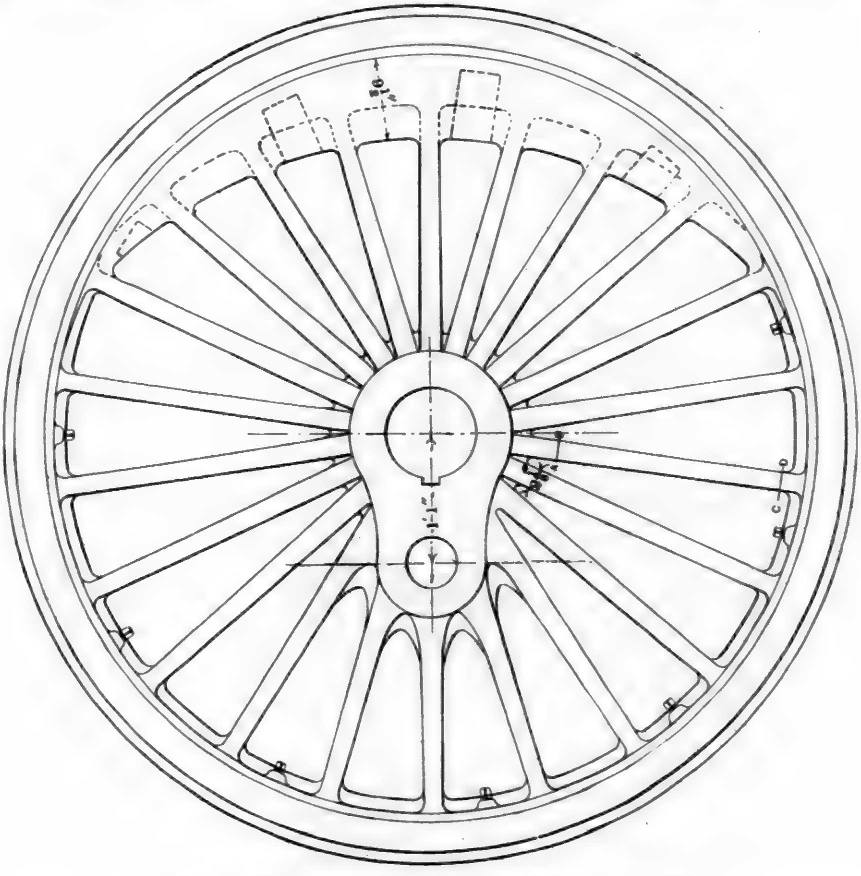
All the axles must be of the very best cast steel, manufactured by Vickers & Company, and must be stamped with the maker's name and date of manufacture. Test pieces are to be made giving a tensile strength of not less than 28 tons, and not more than 32 tons per square inch, with an elongation of not less than 25 per cent. in 2 in.; a piece of suitable length, $1\frac{1}{4}$ in. square, is to be bent double when cold without showing any signs of failure. The bogie axles to have centers of bearings 3 ft. 7 in., $5\frac{3}{4}$ in. diameter, 10 in. long. The driving and trailing axles to have centers of bearings 3 ft. $9\frac{3}{4}$ in., 8 in. diameter, 9 in. long. All axles to be as shown on drawings.

DRIVING AND TRAILING AXLE-BOXES.

The driving and trailing axle-boxes to be as shown on drawing of the best gun metal, and to have bearing surfaces of Dewrance's anti-friction metal; keeps to be of cast iron. The axle-boxes to have lubricating pads as shown. There is to be only one groove in the crown of the axle-boxes, with the lubricating holes leading into it. The axle-box bearings to be $\frac{1}{16}$ in. shorter than the axle journal, to give clearance. The axle-boxes must have $\frac{1}{32}$ in. side play on each of the guides. Each axle-box must be made to gauges and must be duplicates of each other.

DRIVING AND TRAILING SPRINGS.

The springs are to be made of the very best quality of spring steel, manufactured from Swedish bar iron. Five per cent. of the bars to be tested at the works of the makers by the Railway Company's Locomotive Superintendent or his Inspector, in the following manner: A piece to be cut from each bar, 2 ft. 6 in. long, heated and bent round to a radius equal to 80 times the thickness of the bar, then hardened and tempered. The camber to be taken after it has been pushed straight once in the testing machine, after which the bar must be pushed straight six times without showing any further permanent set. The tensile strength of the bars to be not less than 45 tons per square inch, with an elongation of not less than 15 per cent. in 2 in. Manufacture and brand to be approved by the Railway Company's Locomotive Superintendent. The plates are to be truly fitted, tempered, and stamped



DRIVING WHEEL OF ENGLISH EXPRESS PASSENGER LOCOMOTIVE.

with the maker's name and date of manufacture. The plates to be prevented from shifting side or endways by nibs stamped upon them. Care must be taken that the nibs formed on the plates fit the slots properly. The buckles are to be sound forgings and are to fit the springs accurately, and are to be well secured to them, the buckles to be prevented from shifting on the springs by short wrought-iron pins, driven while hot, through holes in the top and bottom of the buckle, and into a hole in the top plate and a recess in the bottom plate, as shown on the drawing. The springs are to consist of 12 plates ½ in. thick and 5 in. broad, to a span of 4 ft., and to have adjustable hangers at the end and solid hangers in the center. Each spring must be thoroughly tested before being put in its place by being weighted with 11 tons, and on the removal of this weight the spring must resume its original form.

SPRING GEAR.

A compensating beam to be attached to the driving and trailing springs, of wrought iron, forged as shown on the drawing, and fitted with a phosphor-bronze bush, pressed into its place by hydraulic power. It is to be carried by a forged cross-shaft, which is to be carried by two forged brackets, as shown. The ends of the springs which do not engage with the compensating beam must be provided with suitable forged hangers, as shown. The whole of the spring gear to be forged in a sound manner, free from all defects whatsoever. The spring and compensating beam brackets to be attached to the frame by ⅞-in. turned cold rivets of best Yorkshire iron, having a tensile breaking strength of not less than 22 tons per square inch, with an extension of not less than 30 per cent. in 2 in.

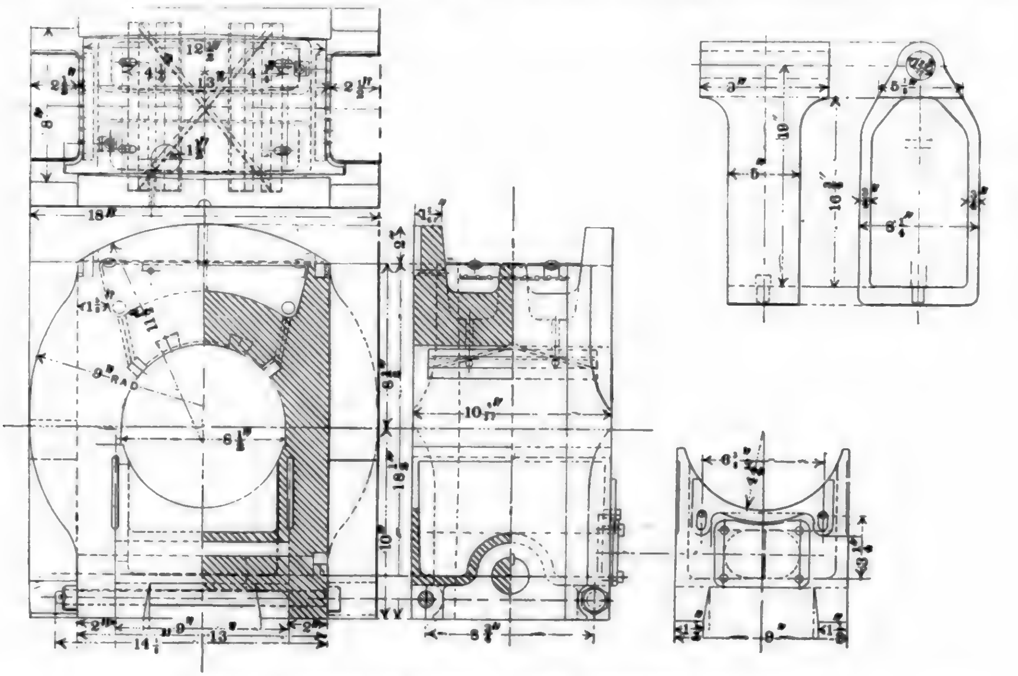
CRANK-PINS.

The crank-pins are to be of the best Yorkshire iron properly case-hardened on the wearing surface. The hole in the wheel is to be parallel as shown; the pins are to be accurately fitted and pressed into the wheels before the tire is shrunk on by hydraulic power of not less than 80 tons, and riveted over on the inside. Cottered washers are to be placed on the ends as shown on detail drawing.

The chief differences in the construction of the parts of the American and English locomotives illustrated this month is in the materials used for the driving-wheel centers—those for the American engine being made of cast iron, and the English centers are made of cast steel. It would be interesting if the weights of these parts could be compared, but unfortunately we are not able to give the weight of either. The tires of Mr. Buchanan's wheels, it will be seen, are secured to the wheel centers by Mansel retaining rings. It must be admited, though, that this practice is seldom followed in this country, and our locomotive tires usually have no other fastening to the wheel centers, excepting the shrinkage of the tire, unless a shoulder is turned inside the tire to bear against the rim of the wheel. Mr. Adams's tires, it will be noticed, are fastened with set screws which are let into holes drilled into the tire, a practice which has been rather severely criticised both in England and this country.

A noticeable feature is that the English axles are made of cast steel, whereas the American are wrought iron. Another is that the English axles are made larger in the wheel-seat than they are in the journals, a practice which is generally followed in English locomotives, and probably adds to the strength of the axle inside of the hub, the point where breakage occurs most frequently. The English axle also has solid collars inside of the journal. When collars are used here they are usually loose and fastened with set screws. They have the advantage that when they become worn they can be replaced or reset on the axle. It will be noticed tha the journals of the American engine are 8½ in. diameter by 11 in. long; those for the English engine are only 8 × 9 in. The larger journals are required for the former, owing to the greater weight carried on them.

In the construction of the crank-pins there is no material difference, excepting that the bearings are larger in the American than in the English machines.



DRIVING AXLE-BOX FOR AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

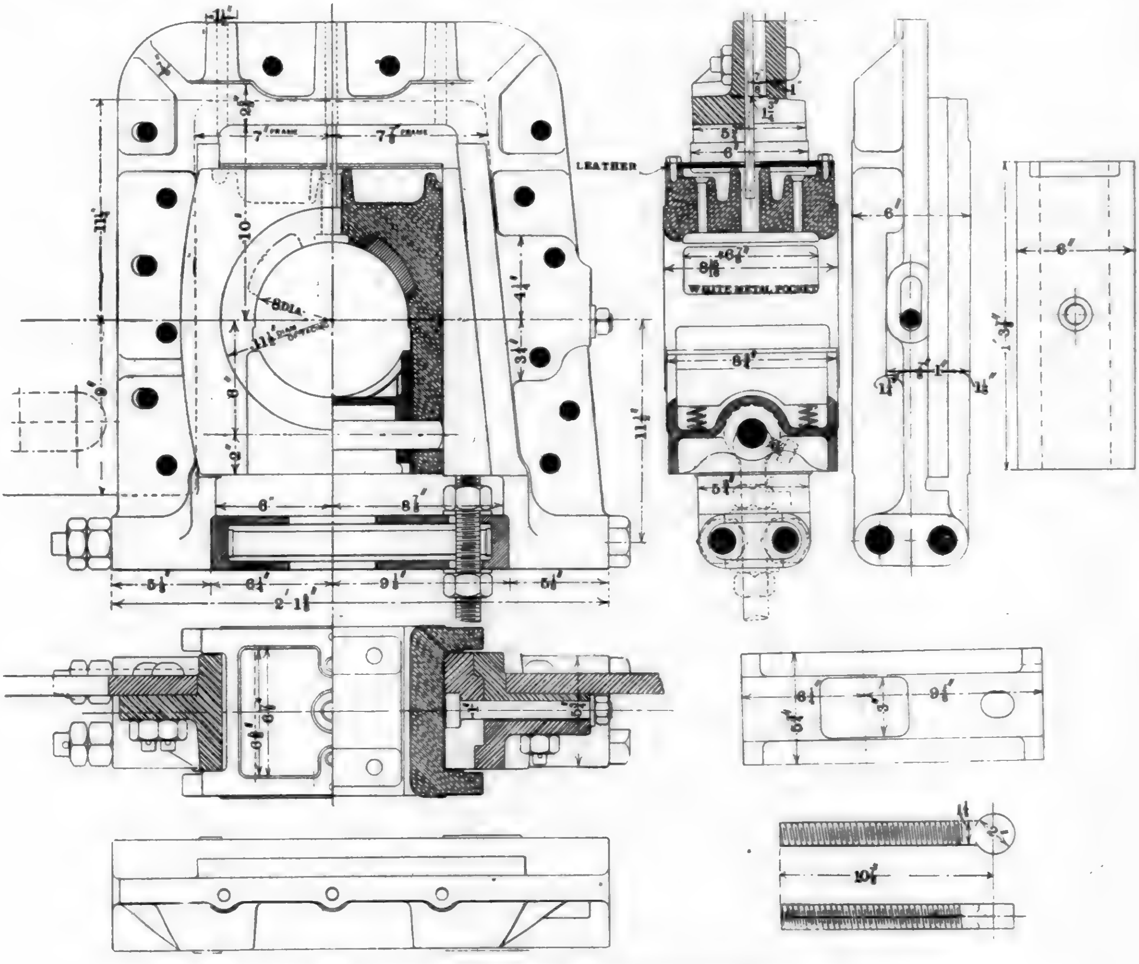
HOME MARINE NOTES.

New Steamers for the Lakes.—A steel steamer is to be built at Wyandotte for the Detroit Dry Dock Navigation Company, which will be an exact duplicate of the *E. C. Pope*. Length over all, 337 ft.; beam, 42 ft.; hold, 24 ft.; diameter of triple-expansion engine cylinders, 22, 35 and 56 in. Howden's forced draft will be applied to the boilers.

Another steamer of 200 ft. keel, 36 ft. beam and 14 ft. hold for the Lake Superior lumber trade, is to be built at Marine City immediately. Estimated carrying capacity, 1,000,000 ft.

Launch of the "Hudson."—The United States Revenue steamer *Hudson* has been launched from the shipyard of John H. Dialogue & Son, Camden, N. J., and will be used as a boarding vessel in New York Harbor in place of the *Manhattan*. Her bows are strengthened with extra heavy plates and framing to resist the ice, which is a wise precaution in view of this winter's experience.

The craft is an iron hull vessel 97 ft. 6 in. long, 20 ft. 6 in. beam, and 10 ft. 3 in. depth of hold. She is fitted with triple-expansion, surface-condensing engines of 475 H P., having cylinders 13 in., 21 in., and 32½ in. diameter by 24 in. stroke. The steam for the engine will be supplied by a tubular boiler of light weight, which has unusual power for a vessel of this size. The boiler is provided with a fan-blower and a closed ashpit system with a forced draft will be used.



DRIVING AXLE-BOX FOR ENGLISH EXPRESS PASSENGER LOCOMOTIVE.

Launch of the "Indiana."—The *Indiana*, the first of the three coast-line battleships, was launched at the Cramp yards in Philadelphia, February 28. She is a high, freeboard ship with water-line armor belt and a heavy protective deck, above which are two armored redoubts carrying turrets. The ship is 348 ft. long on the water-line and 69 ft. 3 in. beam. Her displacement is 10,400 tons, but with a full supply of coal and stores on board she will draw 24 ft. and displace 11,600 tons of water. She will be propelled by twin screws and her engines will be three in number, having 10,000 H. P. The engines will be of the triple-expansion type, will be built abreast in water-tight compartments, and will give a speed of from 15½ to 16 knots, the guaranteed speed being 15 knots. The armor will be as nearly impervious to shot as it can be made. The water-line armor belt will be of 18-in. nickel steel and will extend 196 ft. along each side amidships. At the ends of the armor belt is an armored bulkhead athwartships, which is to be 14 in. thick, and above that and the water-line is to be a casemate belt 5 in. thick. The armament will be as follows: Four 13-in. guns, mounted in pairs in the two main turrets; eight 8-in. guns, mounted in pairs in the four turrets at the corners of the casemate; four turrets at the corners of the casemate, four 6-in. guns mounted in broadsides, with splinter bulkheads back of them; twenty 6-pdr. and rapid-firing guns; eight 1-pdr. and Gatling guns and six torpedo tubes. The armament is very heavy for her displacement, and to some extent the ship is an experiment in that direction.

Trial of a New Solarometer.—Successful experiments have just been made with the solarometer on board the U. S. Lighthouse steamer *Violet*, in the Chesapeake Bay and Baltimore harbor. The solarometer is a nautical instrument, the invention of Lieutenant W. H. Beehler, U. S. Navy. The instrument accurately determines a vessel's position at sea and her compass error by observations of the sun, moon, or stars at any time any one is visible, independent of the visibility of the

sea horizon and without any elaborate calculations. It is mounted on board the steamer and occupies a space of 6 ft. in diameter on the deck. It is arranged with a constant level base a cast-iron float in a large bowl containing 380 lbs. of mercury. The bowl is supported by gimbals on a stand on the deck. The method of observing is to adjust one graduated arc to the declination of the sun or body to be observed as given in the *Nautical Almanac*, and then to turn the telescope to the object in the sky. To get the sun in the axis of the telescope it is necessary to raise or lower the pole of the instrument, and when it is adjusted to be visible in the axis of the telescope, the angle shown by the graduated arc is the vessel's latitude. The latitude, declination and altitude being known, the hour, angle or local apparent time is read on the hour circle, while the azimuth is read on the horizon circle. An index in the line of the keel shows the direction of the true north, and affords means to determine the error of the ship's compass. In a book of azimuth tables, the azimuth corresponding to a certain declination, latitude and azimuth are given. These four quantities must be the same as read from the instrument. Hence, whenever an observation is taken, the observer knows definitely if his results are right or wrong. This feature is peculiar to the solarometer. Further experiments will be made on board the *Violet*. Space for the exhibit of the instrument at the World's Columbian Exposition has been obtained, and the manufacturing of the instruments in quantities will soon be commenced.

The Battleship Iowa.—The *Iowa* will be a formidable battleship. The following are her dimensions: Length on load water-line, 360 ft.; extreme breadth of beam, 72 ft.; displacement at normal draft, 11,296 tons; freeboard forward, 24 ft. The *Iowa* will have engines with a maximum indicated horse-power of 11,000, and she will be able to steam more than 16 knots an hour. She will be able to carry 2,000 tons of coal, and her crew will consist of 436 officers and men. The engines will be rights and lefts, and will be of the vertical, inverted cylinder, direct-acting, triple expansion type. There will be a 39-in. high-pressure, a 55-in. intermediate-pressure, and an 85-in. low-pressure cylinder, each piston having a stroke of 48 in. The working pressure of the boilers will be 160 lbs. to the square inch. The total heating surface of the main boilers will be 23,951 sq. ft., and the grate surface 756 sq. ft. The boilers will be of the horizontal, return 5-tube type. There will be three main double-ended and two auxiliary single-ended steel boilers in the vessel. The battery will be a particularly heavy one and will consist of four 12-in. breech-loading rifles, eight 8-in. breech-loading rifles, six 4-in. rapid-fire rifles, twenty 6-pdrs., four 1-pdrs., four Gatling guns, and 1 field gun. There will be two barbette turrets—one forward and one aft—for the 12-in guns. Four barbette turrets—two on each broadside—will contain the 8-in. rifles. Four of the 4-in. guns will be in armored sponsons on the gun-deck, and the other two will be on the bridge at the extreme end of the superstructure. The 6-pdrs. will be distributed about on the gun-deck, the bridges and superstructure. Two of the 1-pdrs. will be placed in the military tops with the Gatling guns, and two will protect the extreme end of the gun-deck. The hull of the *Iowa* about the water-line region will be protected by a side armor belt 14 in. thick and an average width of 7 ft. 6 in. The hull will be of steel unsheathed. The vessel will have a double bottom and water-tight compartments extending 10 ft. above the load water-line. She will carry no sail and will have but one military mast. The barbettes and turrets for the 12 in. guns will be 15-in. thick. The conning tower will have steel sides 10 in. thick and an armored communication tube 7 in. thick. The barbettes for the 8-in. guns will have a maximum thickness of 8 in. The 4-in. guns will be protected by stationary steel shields, which are really parts of the hull, as they are built into it, forming armored sponsons. Shields and extra side plating will afford protection for the smaller guns. The deck will be of steel of a minimum thickness of 3 in. Transverse armor and a cellulose belt will add to the protective quality of the ship.

REPORT ON THE "VESUVIUS'S" GUNS.

FOLLOWING are the conclusions of the Board appointed to examine the guns and the operation of the gun mechanism of the *Vesuvius*.

In the endeavor to determine the value for naval warfare of the pneumatic guns for discharging torpedoes installed on board the *Vesuvius*, the question of accuracy attracts most attention. Thirty-one of the projectiles fired by the Board for range were dummies and 21 were service projectiles, which, being turned on the outside, are smoother than the dummies. This difference of surface may perhaps affect the range somewhat, but its influence if any did not appear.

After an extended consideration, the Board has decided that, while the accuracy of these guns leaves a good deal to be desired, it is still reasonably sufficient for the purposes of naval warfare in comparatively smooth water, the only condition under which the Board has been able to carry on the tests. The value of the guns is increased by the fact that the projectile contains a heavy charge of high explosives, and also that this explosive can be safely discharged when the projectile that contains it is armed with a fulminate fuse; and though the particular fuse used in the trials has failed to perform its functions, it is evident that it can be safely fired from the gun.

One of the chief merits of the system is that its usefulness begins at about the range where that of the automobile torpedoes now in vogue ceases; and while it is true that daylight is necessary in order to best utilize these ranges, it is thought that a vessel so armed would still be useful at night for annoying groups of hostile ships, firing upon harbors, dockyards, etc. The usefulness of the system at night is increased by the fact that there is no flash or smoke from the guns, and that the report when projectiles are used is comparatively light; indeed, with the vessel to leeward, or if a side wind of moderate force should prevail, it is doubtful whether the report would be much noticed. In the day-time a vessel carrying such guns could successfully attack under cover of fog or smoke or under the shelter or protection of our armored or other ships; she could also be conveniently used in rivers or bays by firing from behind trees or points of land, from which positions she would be able to make fair practice, and owing to the absence of smoke would not be so readily discovered as other vessels.

The Board is aware that the firing of high explosives from powder guns of late years has made progress, and very likely before long the firing of heavy charges from such guns may be generally introduced, and, if so, it is quite probable that the value of the pneumatic guns may be lessened; but it is to be observed that such powder guns have not yet made their appearance in the Navy, and it is uncertain when they will do so. When they do appear perhaps they may prove to be simpler in mechanism and more accurate in practice than the guns of the *Vesuvius*, but the Board has no positive evidence on this point at present, and therefore is uncertain to what extent this superiority may obtain, and are also uncertain to what extent the pneumatic system may be improved. In order to form a judgment as to the comparative accuracy of the two kinds of guns, it would be well to compare the probable rectangles, etc., of the pneumatic guns with those of a rifled mortar or howitzer that would project equal weights of high explosives over equal ranges. But however these matters may ultimately be decided, the Board is of opinion that the pneumatic system, as installed on board the *Vesuvius*, is, on the whole, of decided value in naval warfare, though the fuse is quite defective, and several other points connected with the mechanism of the guns require attention. It is also thought, judging from the comparatively superior endurance of the middle gun, that the system is capable of mechanical improvement, and that the guns can probably be made to work more nearly together than they do now.

The Board has observed the following points in which improvement would be desirable as tending to the most perfect working of the system.

The fiber buffers used in the mechanism do not appear to resist well the hammering of the parts which they cushion; they also appear to swell and flake when much moisture is present, and thus the range and accuracy of the guns is injuriously affected. The buffers should, if possible, be made of some harder and more durable substance.

It would be well if some means were taken to prevent the entrance of undue amounts of moisture into the system, as the presence of moisture affects the buffers as above mentioned.

Valves should be provided to isolate each gun from the others and from the firing reservoirs, in order that a disabled gun could be thrown out and repaired while the others were in use.

SPECIAL TOOLS OF THE DELAWARE & HUDSON CANAL COMPANY'S SHOPS.

THE principal repair shops of the Delaware & Hudson Canal Company are located at Green Island, opposite Troy, N. Y., where the main work for the northern divisions is done, and at Oneonta, midway between Albany and Binghamton, on the Susquehanna Division. The general run of tools in the Green Island shop have been in their places for several years, but continual additions are being made in the shape of special tools of home manufacture, some of which we illustrate in this con-

nection, and will continue the subject in one or two more issues to follow.

It is needless to recapitulate the standard tools in use, for they are such as are to be found in every well-regulated shop; we will, therefore, confine ourselves to the special features of the establishment. The tool room is on one side of the shops, and is equipped with emery grinders, a milling machine of home construction (which we will illustrate in our next issue), and two revolving racks, made like the revolving book cases which are to be found in so many libraries and offices. These racks have five shelves each, which are about 4 ft. in diameter, and possess the advantage of occupying but little wall space, besides enabling a man to stand in his tracks and look over the whole stock of tools and forgings.

The day upon which our visit to the tool-room was made was a cold one in March, but into the oil-hole of the back gearing of one of the lathes there was stuck a slip of a geranium leaf and a brilliant flower. It seemed a little out of place, but spoke well for the taste of the workman, whom we supposed had brought it from home. Our surprise was increased, however, when the next step took us into a well-appointed conservatory filled with a vigorous growth of tropical and the ordinary flowering plants of our summer gardens. The company maintains conservatories at Green Island and Oneonta, where thousands of plants are cared for during the winter, and which are used during the summer for decorating the grounds of the shops and the stations along the line. The work was

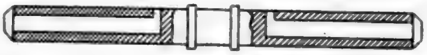


FIG. 1

started, we believe, by Mr. Cory, the Master Mechanic at Green Island, who converted the location of a wild-looking scrap heap into a small hot-bed by means of a few old window sashes. His plants grew and gained in the favor of officers and men, with the result we now find. And curiously enough, Mr. Cory at Green Island and Mr. Smith at Oneonta are both positive in their assertions that this cultivation of flowers results in an actual saving to the company by the spirit inculcated into the men that neatness is the order of the place.

But returning to the purely mechanical features, we illustrate a few handy shop tools that were sketched at Green Island.

Fig. 1 is a section of a convenient form of a rose reamer, for use in a lathe. Any one who has used such a tool in this place knows the difficulty of getting oil down to the bottom of the hole and cutting edges of the tool. In this device there is a

off cylinder packing rings. It consists merely of a piece of 4 in. × ¾ in. iron bent to the shape shown in the elevation, and drilled and tapped for the two set screws on the side. The tools are held to the proper distance apart by a separating strip planed to the proper thickness.

Fig. 4 illustrates a convenient form of boring bar for driving-boxes. It is 2½ in. in diameter, and has a spline laid in it from end to end. A sliding head, shown by the cross-hatched outline, slides over it. At one end it is recessed to receive the tool shown in fig. 5. The center hole in the tool admits a screwbolt by which it is fastened to the head. The two smaller holes on either side are threaded and furnished with set screws, which bear against the bottom of the tool slot and

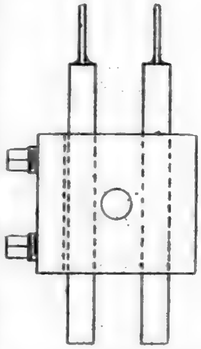


FIG. 2.

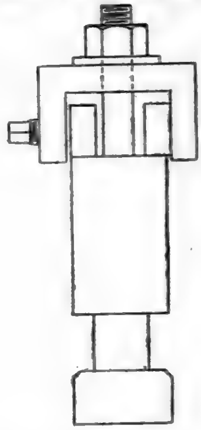


FIG. 3.

serve to make the adjustments for the proper gauging of the tool to the cut. The driving-box is strapped to the body of the lathe, while the head is driven for feed by an offset bar held in the tool post, as shown in the engraving. The wrinkle is doing such excellent work that it is well worth copying.

In the Oneonta shops there is a home-made pipe-cutter and threading tool, shown in figs 6, 7 and 8. Fig. 7 is a side elevation. The pipe is held by the vise *A*, which is shown screwed together in fig. 8, and which with its whole frame can

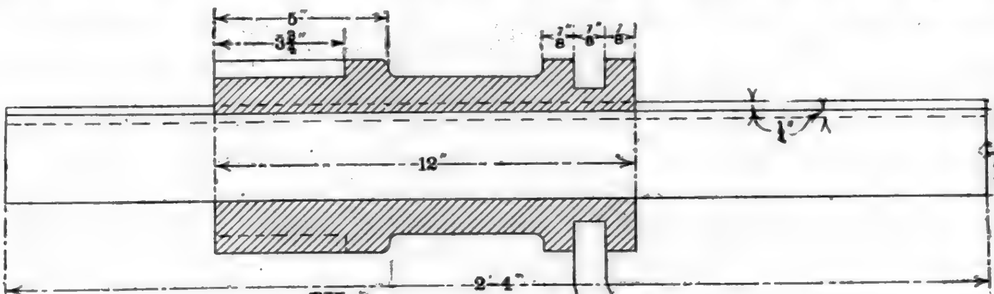


FIG. 4.

FIG. 5

hole drilled in some distance from the end, into which a side hole leads, through which the oil is introduced. The central portion is flattened for the purpose of more convenient holding with the dog. The reamer shown is of the double-ended variety.

Figs. 2 and 3 show a plan and back elevation of a convenient form of tool holder for carrying two cutting-off tools at the same time. At the Green Island shops it is used for cutting

slide ahead on the bars *B B*. The dies are placed in the chuck *C*, which is held upon a hollow spindle that is driven by the gear *D*. Hand-power is used to drive it at present. The large pinion at the right being used for the smaller sizes of pipe, but when anything above 1¼ in. in diameter is to be cut or threaded, this pinion is slipped out of mesh with the gear and the small one brought into play. This latter can also be thrown out of mesh when it is not in use. The machine stands upon

a bench, and the general size may be estimated from the fact that the pitch circle of the main gear is 21 in. in diameter.

There is also to be seen about the Oneonta shops a very strong and convenient form of hand-truck, of which we give engravings. While there is nothing startlingly novel about it, it serves its purpose well, and we present it because it may save time to some of our readers who need such a convenience and who have neither the time nor opportunity to make a drawing. As the drawings show the construction very clearly, and as most of the dimensions are given, we may pass on at once to the

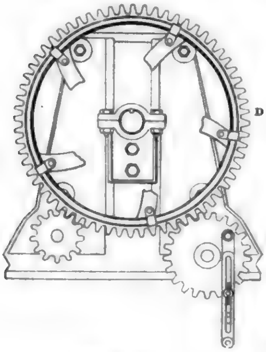


Fig. 6.

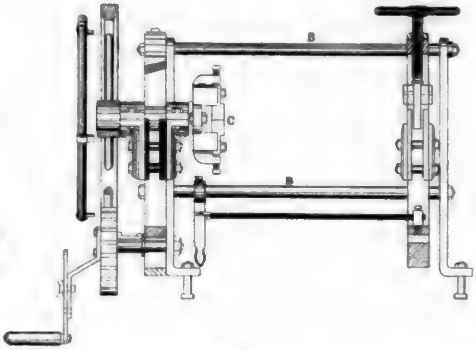


Fig. 7.

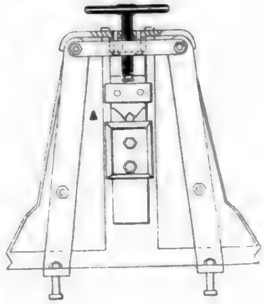
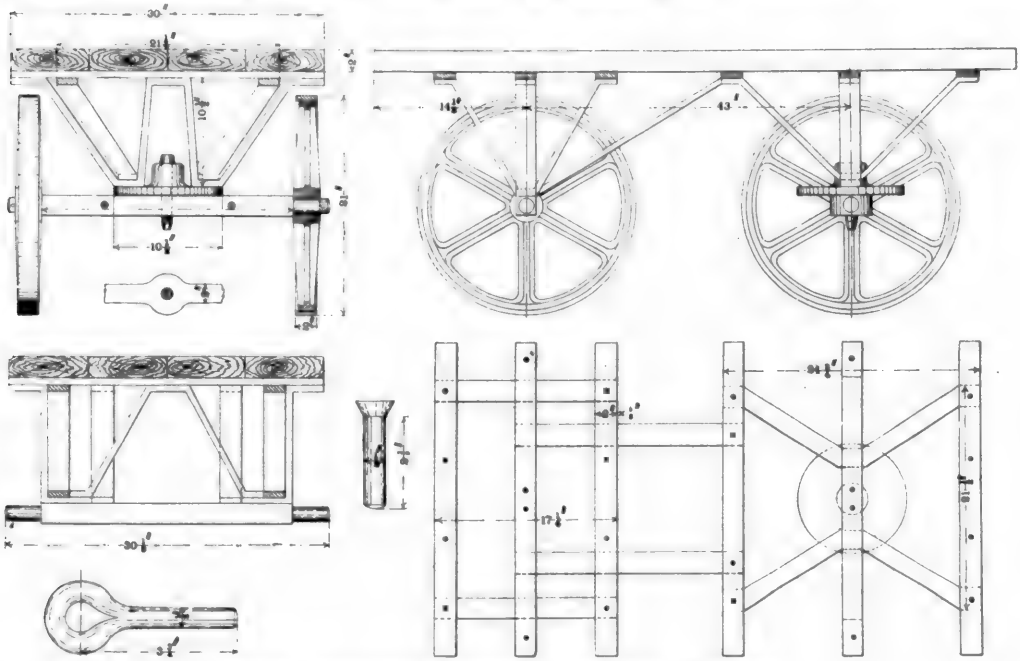


Fig. 8.

HYDRAULIC CRANE FOR CAR WHEELS.

Hydraulic power is very extensively used at Oneonta, Green Island and Whitehall, and we shall publish a number of interesting tools that have been built at the shops in which a water pressure is used as the motive power. The water is usually taken from the village or city mains, which are under a constant pressure of from 75 lbs. to 90 lbs. per square inch. But when the pressure falls below these figures for any reason, there is a pump in the shop which is utilized to maintain that required for the operation of the hydraulic machinery.

The crane here illustrated is one that stands between a couple of wheel borers in the Oneonta shops. The post consists of a length of wrought pipe closed at the bottom and furnished with a step. Water is admitted at the top and led off near the bottom at a convenient height for the man operating it to handle the valves. The cylinder, which is held rigidly by the two arms, has an internal diameter of 4⅝ in., with a shell ½ in. thick. The stroke is 5 ft. 3 in. The piston-head is provided with a double leather packing, so that in case the friction is too great for the unloaded tongs to lower, a pressure can be admitted at the top to force the piston-head down. The work is done rapidly and silently, about two seconds being required to lift a wheel from the floor. The lift being direct, there is nothing at all to get out of order.



ONEONTA SHOP TRUCK, DELAWARE & HUDSON CANAL COMPANY.

HYDRAULIC BOOM CRANE.

This crane stands out of doors at one end of the Oneonta shops, and is used principally for loading and unloading shop materials and supplies, a large proportion of the work consisting of the handling of car wheels. The construction is exceedingly simple. There is a solid hollow mast, beneath and central with which is the direct acting hydraulic cylinder with a

stroke of 7 ft. 10 in. The piston of this cylinder, also, has a double leather packing, so that it may be forced up in case the frictional resistances are too great for the empty chain to haul it. The cap of the post has a male center which takes a collar at the inner end of the boom and carries the horizontal pull due to the load. The thrust at the foot is taken by two rollers, one on either side of the strut, which travel over a track cast on the base of the column. A four-way valve is used, a section of which is given. It will be seen that the pressure may be admitted to the top or bottom end of the cylinder, and the exhaust water let off from the opposite end at the same time.

Persons who have had no experience with the use of hydraulic machinery are apt to think that in this climate there is great danger of freezing; but this is not the experience on the Delaware & Hudson. This crane is out-of-doors, and though the past winter has been one of unusual severity, there has been no trouble from freezing. The only precaution that was taken was to lay bare a steam pipe which passed through the pit.

The above are a few of the many interesting features to be found in and about these shops, the illustrating of which will be continued in our next issue.

THE EFFECT OF TEMPERATURE ON THE STRENGTH OF IRON.

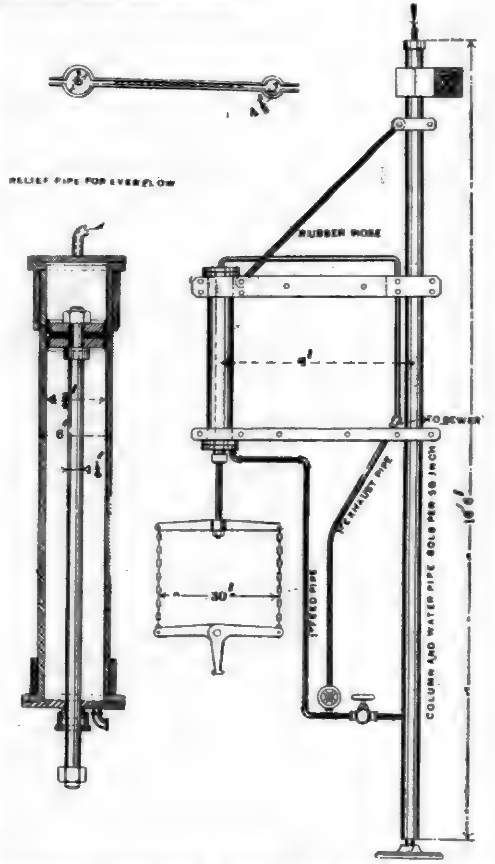
This subject has attracted considerable attention on account of its importance in connection with steam boilers and other structures that are exposed, when in use, to a temperature several hundred degrees higher than the ordinary temperature of the air; but notwithstanding the interest that engineers have taken in the matter there seems to have been but little done in the way of experimental investigation.

The first experiments bearing upon the influence of temperature on the strength of iron, so far as we know, were those made by the Franklin Institute, in 1833, and published in the *Journal* of that institution in 1837. There is a difference of opinion among the authorities as to what these experiments really show, but they have usually been considered to show that iron grows stronger when its temperature is raised from, say, 60° up to 500° Fahr. Chief Engineer Isherwood of the U. S. Navy has criticised the method in which they were carried out, and has pointed out a source of error to which they are doubtless liable.

Ten years later, in 1843, Baudrimont made a series of experiments with wires of gold, platinum, copper, silver, palladium and iron. According to Isherwood, Baudrimont's average results for iron were as follows; Strength of iron wire, per square inch of section, was 295,000 lbs. at 32° Fahr., 279,000 lbs at 212° Fahr., and 301,000 lbs. at 392° Fahr. These results are interesting, but they are of no particular importance, because iron wire is a very different thing from boiler-plate, or bar iron.

In 1856 Sir William Fairbairn published the results of his experiments. They indicated that the strength of common boiler-plate is not materially affected by ordinary changes in temperature, but that as a dull red heat is approached the tensile strength falls rapidly. He says: "I have completed a series of experiments on wrought-iron plates and rivet-iron at various temperatures, from 30° under the freezing-point to red heat. These experiments are the more satisfactory as they exhibit no diminution of strength from 60° to 400°; but an increase of heat from that point to a dull red heat shows a considerable reduction of strength and a great increase of ductility, the plates being in the ratio of 20.3 to 15.5 tons per square inch, as regards strength, and the rivet-iron as 35 to 16. The iron suffers little or no diminution in its powers of resistance up to a temperature of 500° Fahr."

Next in order, after Fairbairn's experiments, came those made by the British Admiralty at the Portsmouth (England) Dockyard, in 1877. The specimens to be tested were heated in an oil bath, and "the dies for gripping them were also so heated. The process of fixing and breaking occupied about one minute, during which care was taken to prevent, as far as possible, loss of heat by radiation and conduction." The temperature of each test-piece was recorded as equal to the temperature of the bath in which it was heated. Owing to the cooling of the specimens, and the suddenness with which they had to be pulled apart in order to compress the whole experiment into one minute, we cannot consider this series of tests to be very satisfactory, although it made an acceptable addition to what was then a very meager knowledge of the effect of temperature on the strength of iron. The general conclusions that were reached by the committee having charge of these tests were as follows: "Wrought-irons, Yorkshire and re-manufactured, increase in strength up to 500°, but lose slightly in ductility up to 300°, after which the ductility increases up to 500°, at which point it is still less than at the ordinary temperature of the air. The strength of Landore steel is not affected by temperature up to 500°, but its ductility is reduced more than one-half."



HYDRAULIC WHEEL LIFT, DELAWARE & HUDSON CANAL CO.

Results of Dr. Huston's Tests in 1877.

Material Tested.	Thickness.	Net Width.	Net Sectional Area.	Breaking Weight.	Strain per sq. in. of Original Area.	Strain per sq. in. of Fractured Area.	Averages of these Strains.	Contraction of Area.	Temperature of Specimens.
	In.	In.	sq. in	Lbs.	Lbs.	Lbs.	Lbs.		
Cold blast iron.	0.385	0.622	0.239	12,500	52,300	70,600	61,450	.26	68° F.
" "	.385	.629	.242	16,200	66,940	87,600	77,270	.24	575°
" "	.380	.623	.236	16,550	70,130	90,000	80,065	.22	925°
Otis steel......	.335	.642	.215	12,000	55,800	113,200	84,500	.50	68°
" "	.345	.639	.214	14,200	66,350	111,000	88,675	.40	575°
" "	.335	.640	.214	13,750	64,250	94,830	79,540	.32	925°

In the same year (1877) Dr. Charles Huston of the Lukens Rolling Mills, Coatesville, Pa., made some tests bearing on this question, at which we were present by his invitation. As they have never been published it may be of interest to give a brief account of them. The test strips were a little less than 1 in. wide and about ⅜ in. thick, and through the middle of each piece a ¼-in. hole was drilled. These holes were filled with fusible alloys, whose melting points were determined beforehand with considerable accuracy. By reducing the sectional area of the piece, the hole also determined

the point of fracture. In making a test the piece was fixed in the jaws of the testing machine, and warmed along the central portion, as uniformly as possible, by a Bunsen burner. The piece was gradually put under tension at the same time, and when the strain upon it had approached its tensile strength the machine was stopped until the fusible alloy was seen to be fairly melted, and the piece was then broken by a slight additional pull. It was considered that in this way a very fair idea might be had of the effect of temperature upon the pieces tested. Six specimens were fractured in all. Three of them were cut from plates of the best flange boiler iron, made from cold blast charcoal blooms, and the remaining three were samples of Otis steel, furnished by the Baldwin Locomotive Works of Philadelphia. The results are given in the accompanying table.

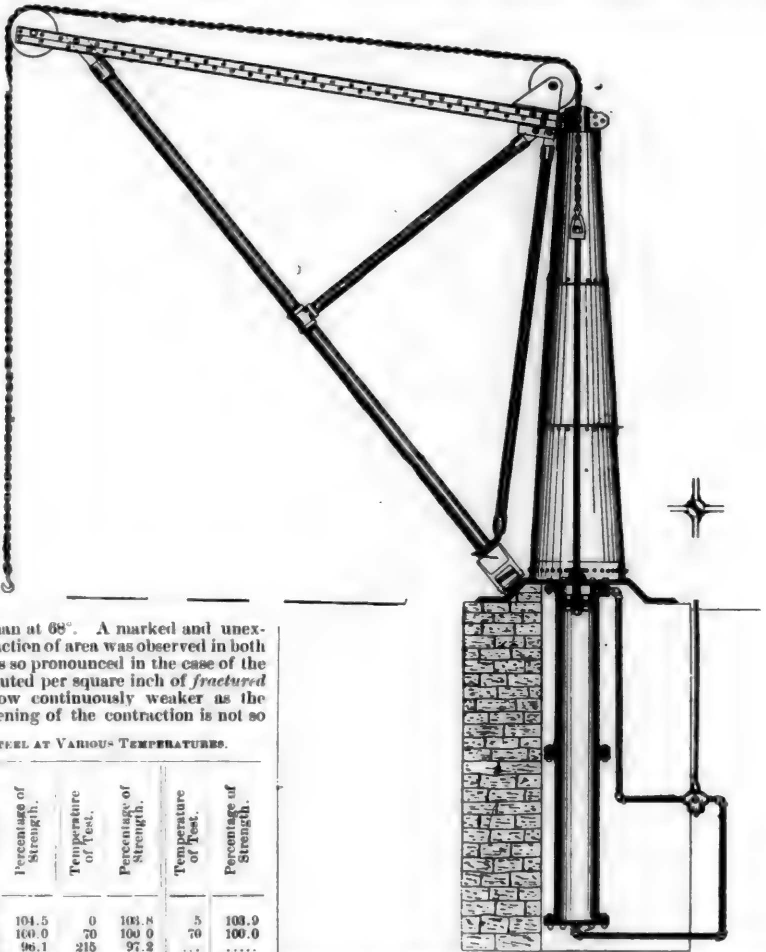
The column headed "net width" gives the width of the piece after the diameter of the hole has been deducted and the "net sectional area" is obtained by multiplying the net width by the thickness. It will be noticed that the iron shows a material increase in strength as the temperature rises. At 78° it broke at 52,300 lbs. per square inch of original section, but at 575° an additional stress of 7 tons per square inch was required in order to break it. The iron even shows a gain in strength between 575° and 900°, but it is doubtful if all pieces would show a gain in strength at this place, for at 925° we are approaching a red heat. The steel also showed a pronounced gain in strength per square inch of original section, as the temperature rose from 68° to 575°, but after this point was reached it fell off again, though even at 925° it remained materially stronger than at 68°. A marked and unexpected falling off in the contraction of area was observed in both the iron and the steel. This is so pronounced in the case of the steel that if the strain is computed per square inch of *fractured* area the steel appears to grow continuously weaker as the temperature rises. The lessening of the contraction is not so

THE TENSILE STRENGTH OF STEEL AT VARIOUS TEMPERATURES.

Temperature of Test.	Percentage of Strength.	Temperature of Test.	Percentage of Strength.	Temperature of Test.	Percentage of Strength.	Temperature of Test.	Percentage of Strength.	Temperature of Test.	Percentage of Strength.
0°	104.8	0°	104.3	0°	104.5	0	103.8	5	103.9
70	100.0	70	100.0	70	100.0	70	100 0	70	100.0
195	97.2	201	96.1	228	96.1	215	97.2	...	.....
384	117.4	306	100 3	339	109.3	317	102 6	272	101.6
400	125.8	437	111.9	431	111.7	440	115.4	448	113.6
492	122.2	545	116.8	569	116 4	570	115 9	503	115.6
616	123.4	668	114.5	651	106.4	642	112.8	594	115.4
741	102.5	736	101.4	738	103.1	757	106 0	712	98.1
845	[illegible]	869	86.2	832	102.0	....	....	861	94.0
934	81.0	959	72 3	960	85.6	912	85.5	....	.....
..	.....	1050	57.2	1021	68.5	1080	75.3	...	.....
1045	47.3	1176	39 2	1198	45.1	1192	48.7	1113	54.5
1235	33.0	1307	30.7	1351	38.7	1395	42 9	1319	35.6

marked in the iron test pieces, so that these exhibit an increasing strength whether the original or the fractured area is considered. Although these experiments were not numerous enough to serve as the basis of any very broad generalizations concerning the effect of temperature on the strength of iron, we considered that they showed that iron is *at least as strong* at boiler temperatures as it is at the ordinary atmospheric temperature; and hence we felt safe in designing boilers without regard to the possible change in tensile strength that the metal might experience when heated to 300°, 400°, or even 500°.

The most extensive series of tests bearing on the effect of temperature, so far as we know, are those carried out recently at the Watertown Arsenal, with the great testing machine. The specimens were heated by rows of Bunsen burners, which were arranged in a muffle; and the temperatures of the test specimens were inferred from their observed expansions. Each piece was heated to the temperature of the test before being strained, and its expansion was observed by a micrometer. The coefficient of expansion of each grade of metal had been determined before the tests began, so that the temperatures could be inferred with considerable precision. It will be impossible to give the results of these tests in detail in this place, but the foregoing abstract of five of them shows quite well that the strength of steel is greater at about 500° Fahr. than it is at 70°. The temperatures are all on the Fahrenheit scale.



HYDRAULIC CRANE, DELAWARE & HUDSON CANAL COMPANY.

These five series of tests were made with five different qualities of steel, containing, respectively, .09, .20, .31, .37, and .51 per cent. of carbon. The figures given in the columns headed "Percentage of Strength" were obtained by dividing the tensile strength of a sample of steel at the given temperature by the strength of the same quality of steel at 70° Fahr.

It will be seen that these specimens were all stronger in the neighborhood of zero than they were at ordinary temperatures; and that, in fact, they all show a *minimum* of strength at 210°, or thereabouts, and a *maximum* of strength at about 550°. This curious property of iron may now be considered to be well established; and it deserves further attention than it has yet received.—*Locomotive.*

SHELLS WITH HIGH EXPLOSIVES.

As the Dashiell mechanism for quick-firing guns of large caliber has been adopted by our Navy, we give below a description of it, taken from the *Annual No. XI.* of the Office of Naval Intelligence, supplementing it by a description from the same source of the Fletcher mount for large rapid-fire guns. It may be noted here that the use of rapid-fire guns of large caliber is a marked feature in recent changes in naval ordnance.

THE DASHIELL MECHANISM FOR RAPID-FIRE GUNS.

The fermeture is on the slotted-screw system. The plug is supported, when withdrawn, on a hinged tray and collar of suitable shape. All the operating mechanism is carried on the tray casting, except the trigger, which is on the gun.

A curved translating arm of bell-crank lever form is pivoted to the tray at one end. A vertical toe at the other end engages an undercut score in the breech plug. When this lever swings on its pivot, the plug, if unlocked, will be withdrawn from or entered into the breech.

In the elbow of this arm is pivoted a horizontal cogged segment, formed in one piece, with a long lever ending in a vertical handle, or grip. A curved slot in the tray allows its pivot-pin to move with the pivot of the translating arm as a center during longitudinal motion of the plug on the tray. This cogged segment engages a series of horizontal cogs on a rack bar which slides in a groove in the front of the tray. The left-hand end of this bar is provided with vertical cogs engaging another series on the lower part of the breech plug. A stop-pin on the face of the breech limits the travel of the rack. The length of the rack is such that its extreme right-hand cog is immediately below the pivot-pin of the translating arm when the plug is unlocked.

The usual double-acting latch is fitted to the tray.

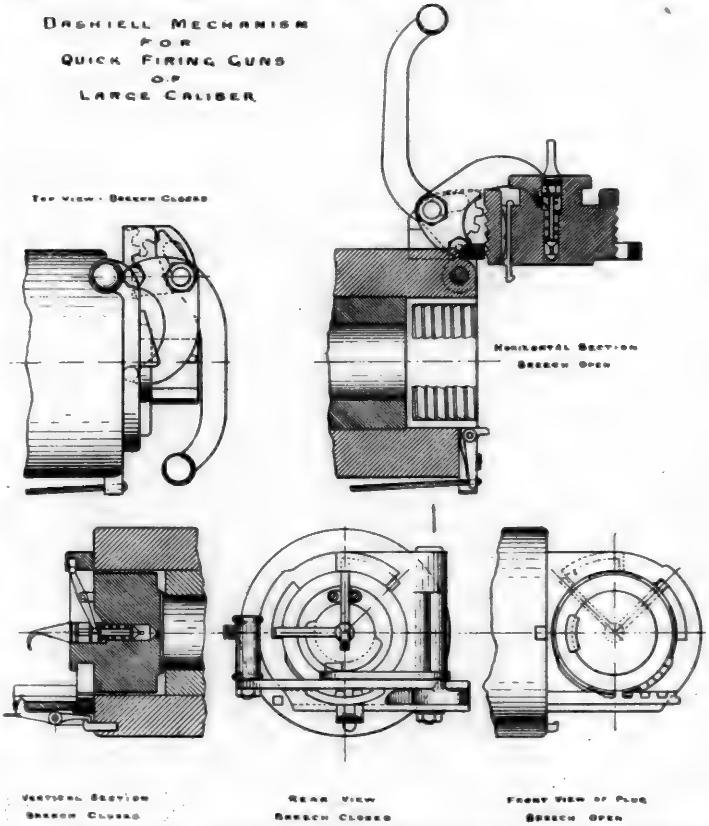
The plug being locked, a pull on the hand-lever rotates the cogged segment, thus unlocking the breech plug by means of the rack-bar described. As soon as the plug is unlocked the stop-pin will have checked the motion of this rack, and the center of motion will be transferred to its right-hand cog, which is now immediately below the pivot-pin of the translating arm. The arm and lever consequently swing together, and the plug is withdrawn on the tray and swung to one side clear for loading. As the plug comes out a groove cut in its threaded lower segment passes over the central tooth of the rack.

In returning the plug to the breech two forces will be at work in the mechanism—one to rotate the plug, the other to push it home. The first is checked by the groove in the plug engaging the tooth of the rack mentioned and pulling the plug against the tray-rib. Only the motion of translation can thus take place. As soon as it is entirely off the tray-ribs the plug can revolve, but being then home in the breech its translating motion ceases and revolution locks it in place.

The extractor is a strong bar kept down by a mild spring. It passes through a hole in the plug so as not to interfere with the threaded parts. By utilizing a certain amount of fore-and-aft lost motion the extractor is kept from slipping off the cartridge-head at the same time that the plug, when pulled quickly to the rear through this lost distance, acts very powerfully as a hammer to extract the empty case.

The extractor is shown in its forward or pulling position. When pushing a cartridge home the extractor-hook cannot rise and catch until it has been pushed back, by the forward motion of the plug, to its rear position. It can then snap over the rim of the case, and is ready for the blow from the breech plug in extraction.

The firing mechanism consists of a straight firing-pin, with cone-shaped shoulder and finger-hook. A spiral spring actuates it, being held to its work by a loose, spool-shaped sleeve. A cocking-lever is pivoted to the plug, its upper end running along a cam groove in the tray collar, while its lower end is forked to engage over the spool-shaped sleeve on the firing-pin. When unlocking this lever moves the sleeve to the rear, cocking the pin on the toe of a horizontal sear-bar. When locking, the sleeve is given motion in the opposite direction, which compresses the spring, leaving the firing-pin cocked. When fully locked, the outer hook of the sear engages the trigger.



It will be seen that the gun cannot be fired unless the main-spring is compressed and the sear and trigger engaged, neither of which takes place until the last instant of locking.

The lanyard leads forward, around a pulley near the trunnions if desired, so that the gun captain and lanyard will be out of the way of the gun servants about the breech, and the pull for firing will be independent of the elevation of the piece.

The advantages claimed for this mechanism are efficiency and cheapness of manufacture. The quick-acting part is applicable to any gun with slotted screw fermeture in which the breech-plug is worked by manual power.

Five rounds have been fired in 17 seconds from the naval 4-in. gun fitted with this mechanism, the gun's crew having been drilled for two minutes before the salvo was fired.

RAPID-FIRE GUN MOUNT.

The rapid-fire gun mount designed by Lieutenant F. F. Fletcher, U.S.N., has been so modified that a description of it as finally adopted for the 4-in. rapid-fire guns is given, reference being made to the accompanying drawings.

Carriage.—The band B screwed on the gun at its center of gravity has cast on its under side the recoil cylinder F, and on its side the lugs b_1 b_2 and b_3, figs. 1 and 2. These lugs slide in corresponding recesses in the sides of the rocking frame C, which frame takes the weight of the gun, furnishes the trunnions D, and acts as the guide during recoil. The upper carriage is composed of the two side-brackets K, which support the trunnions and carry the transverse axles S and S^1 of the training and elevating gear, and of the front and rear transoms L and L^1. The transoms and brackets are bolted to the base-plate M, which is provided on its under side with the cylindrical shoulder m^1, fitting over the central pivot n_2, and has bolted on the outside the clips Q, two in front and one in rear, which, with the bolt D, prevent the carriage from lifting. Let into the under circumference of the base-plate is the ring m, resting on a double row of steel balls n^1, which fill grooves in the corresponding ring n of the pivot stand N, thus providing a ball-bearing surface for the upper carriage to revolve upon. The pivot stand N is bolted to the deck, and carries the circular rack u^1, for training in direction.

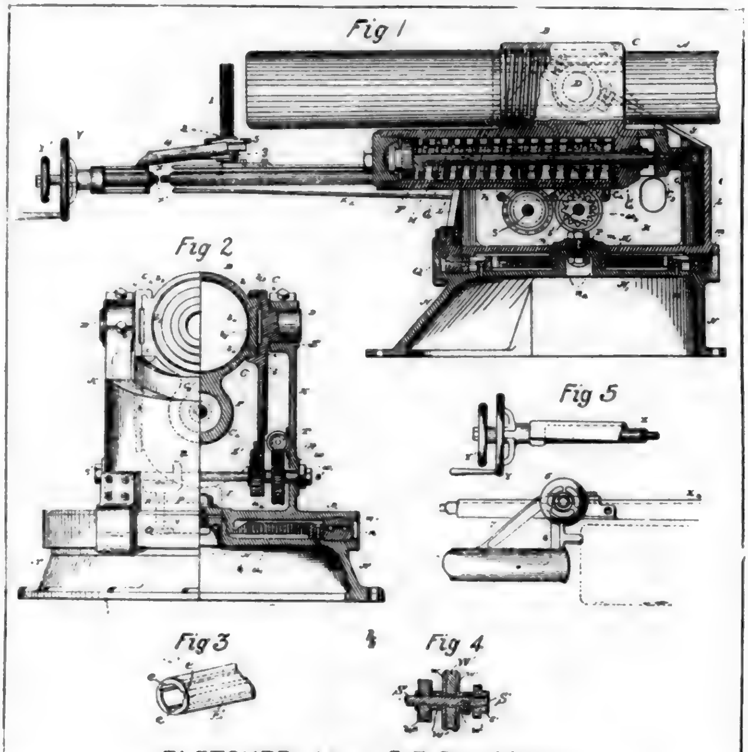
Training gear.—The training shaft X (fig. 1), on the left side of the gun, is hollow, and works by means of the hand wheel Y, independently of the elevating shaft X^1, which is contained within it and which is manipulated by the wheel Y^1. On the front end of the shaft X is the worm T (fig. 2), which actuates the worm-wheel W, on the rear axle S, and, through them and the pinions R and R^1, the cogged wheel (not shown) on the vertical axis v; this cogged wheel gears into the circular rack u^1, and revolves the carriage.

Elevating gear.—Cast in one with the rocking frame C is the quadrantal arm C^1, to the lower end of which is bolted the cogged arc C_2. Keyed to the forward end of the interior or elevating rod X^1 (fig. 1), and in front of the training worm T, is a similar worm working in a worm-wheel on the forward axle S^1 (fig. 1); on this axle is the cogged wheel u_2 (figs. 1 and 2), which, gearing in the cogged quadrant C_2, causes the gun to swing about the trunnions D, as an axis, when the hand-wheel Y^1 is turned.

In order to permit of quick training without the use of gearing, and also to avoid damage from excessive strains, the worm-wheels W and W^1 are loose on the shafts S and S^1, being held by frictional disks. Fig. 4 shows one of these wheels, S^1 being the axle, W^1 the worm-wheel, w w the friction disks, and w^1 w^1 sliding collars which hold, or are in one with the disks; w^2 is a set collar, and s^1 a screw nut. By setting up or loosening the nut, the frictional bearing of the disks may be regulated at will.

Recoil check.—The hydraulic recoil cylinder F (fig. 1), referred to above as being cast in one with the screw-band B, contains the liquid, the piston and rod G, and the spiral spring H for return to battery. The forward end of the piston passes through a stuffing-box in the cylinder, and is secured by right and left-handed nuts e_1 e_2 to the front arm e_3 of the rocking frame C. The spring H is set in place with an initial tension, so that it tends constantly to force the gun into firing position. Grooves of varying cross-section are cut in the interior of the cylinder (fig. 3), by which the flow of liquid from the front to the rear of the piston, during recoil, is controlled.

Loading tray.—A loose collar 3 (fig. 1), on the vertical screw 1, carries, by the arms 7, 8 (fig. 5), the loading tray 4. This tray is swung clear before firing the gun, and into the position shown in fig. 5 after the discharge. It is raised or lowered by the wheel 5 and nut 2 working on the screw 1, so that it can always be brought into position for loading without changing the gun's elevation.



FLETCHER 4-inch R.F. Gun-Mount.

LIQUEFIED ATMOSPHERIC AIR.

Professor Dewar recently delivered an address on Liquefied Atmospheric Air at the Royal Institution. An experiment with liquid ethylene, boiling at − 100° C., showed that the evolution of gas was largely increased by warmth, although the temperature of the boiling liquid remained constant, while on placing the bulb containing the liquid ethylene in a bath of liquid carbonic anhydride, boiling at − 80° C., the evolution of gas was greatly diminished. That conduction rather than convection was the chief cause of evaporation was evident from the fact that if the vessel containing the liquefied gas was surrounded by a highly vacuous space, by being contained in another larger vessel, the annulus being exhausted of air, the liquid might be kept much longer. While the annulus was vacuous, 170 unit volumes of gas were evolved in a unit of time, but when air was admitted into the annulus, 840 unit volumes, or practically five times as much gas, was evolved.

Some experiments were then made with liquid oxygen boiling at − 180° C. It was shown to be a blue transparent liquid

containing some floating particles, probably of solid carbonic anhydride, and its increased stability when placed in vessels surrounded by a vacuum was demonstrated. The lecturer then produced liquefied air in an open tube, which was immersed in a larger vessel containing liquid oxygen—this latter being connected with a vacuum pump, the evaporation of the liquid oxygen causing the temperature to fall to − 210° C. At such low temperatures oxygen will not inflame a glowing taper. Liquid oxygen placed between the poles of an electro-magnet is attracted to the poles on a current being passed. When thrown on the surface of water, it enters into the spheroidal state, a cup of ice being formed beneath it and evaporation taking place quietly; liquid ethylene, however, on being placed in water, gives rise to small explosions. When poured under the surface of water placed in a vessel between the poles of an electro-magnet, liquid oxygen was still attracted to the poles when an electric current was passed through the magnet. Professor Dewar stated that he had not succeeded in obtaining solid oxygen.

Air substantially liquefied as one substance, although at ordinary atmospheric pressures there was at least 10° C. difference in the boiling points of its constituents. When liquid air was placed between the poles of an electro-magnet and the current passed, it was attracted to the poles as a simple body, although nitrogen alone was non-magnetic. On exposure to air in an open vessel the nitrogen distilled off first, the evolved gas being for some time a non-supporter of combustion.

An examination of the optical properties of liquid oxygen showed that the law enunciated by Dr. Gladstone for bodies at ordinary temperatures—that the refractive index divided by the density is a constant quantity—held good for oxygen in the liquid as in the gaseous condition.

The production of these liquefied gases had led to determinations being made of the electrical resistances of substances at extremely low temperatures. It had been found that the resistances of metals diminished to a remarkable extent, and it was very probable that at the absolute zero of temperature (− 274°C.) pure metals would have no resistance whatever, becoming perfect conductors; with alloys very little change occurred as the temperature diminished; while with carbon the resistance increased enormously at the lower temperatures, the minimum resistance being at the temperature of the electric arc—about 3,500° C.

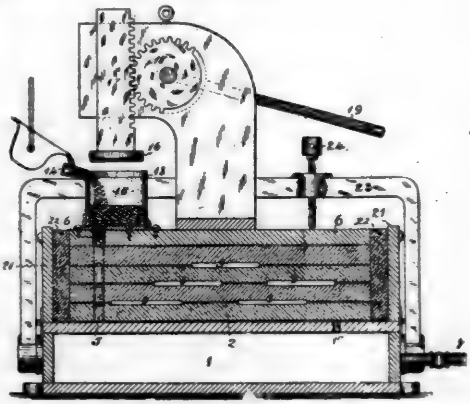
The possibility of obtaining these extremely low temperatures had also been of service in another direction. By carefully filling a tube about 36 in. long and closed at one end with mercury, and then inverting the open end in a trough of the same metal, a space about 6 in. long will form at the upper end. This is vacuous, save for the vapor tension of the mercury at the temperature of the surrounding atmosphere. At ordinary temperatures this pressure is about one-millionth of an atmosphere; at 0° C. (the freezing-point of water) it is one six-millionth of an atmosphere; while at − 80° C. it is only one four-hundred-thousand-millionth of an atmosphere. By placing some mercury in a double-bulbed vessel, boiling the metal to expel air, and sealing the bulbs, a vessel containing only mercury vapor can be obtained. By applying intense cold to these sealed vessels, as by the application of liquid oxygen to their surfaces by means of cotton wool or other suitable absorbents, the mercury vapor will condense and form a mirror on the inner surface of the vessel, and in this manner extremely rarefied vacua, which it is impossible to produce by other means, may be obtained.—*Industries.*

THE SMITH PRESSURE CASTING PROCESS.

Some remarkable work in fine castings has been done by the Passaic Art Casting Company, of Passaic, N. J., which works under several patents recently granted to John J. C. and Victor E. Smith. The work in bronze, brass and aluminum is very fine, the lightest and most delicate patterns being reproduced with great accuracy and fine finish. The process has not, as yet, been applied to iron or steel.

The casting apparatus, which is shown herewith in section, consists of an air-tight cast-iron box, of suitable size to contain a number of the molds properly piled and packed so as to be immovable in the box. An opening in one end of this box, opposite from the end nearest the sprue, connects it to a large tank, in which a vacuum may be created and maintained by any convenient means. An opening in the cover plate of the box directly connected with the sprue leads into a cylindrical reservoir containing the molten metal. This cylinder is lined with asbestos felt, the hole into the sprue being also covered with it, preventing the exit of the metal from the reservoir, until the proper time. A piston, covered also with asbestos fits closely into the cylinder, and pressure may be applied to it by hand through the action of a lever, rack and pinion, a screw or by other means. The reservoir being filled with the proper quantity of molten metal and the piston entered into the cylinder, connection may be opened between the mold and the vacuum tank, causing the air in the mold to be drawn out, and at the same time pressure of any required degree may be applied to the piston. This pressure bursts that portion of the asbestos lining that lies immediately over the hole in the cover plate, and the metal is instantaneously shot into every portion of the matrix in the mold.

Referring to the engraving, 1 is a chamber under the mold box, which connects with it through the opening 1 *a* and with the vacuum tank through the pipe 7. The molds are shown at 2, their matrix spaces at 3, the sprue at 5, horizontal lines from 3 to 5 representing the channels or gates. The reservoir with its asbestos lining is seen at 15, with the metal runner at 14 and the piston at 16. Between the molds 3 and the sides of the box, 21, there is shown a loam tamping, 22. Screws 24 tapped into the yoke 23 enable the cover or cope to be forced down firmly on the mold. The use of the rack, pinion and lever, 17, 18 and 19, is clearly seen.



SMITH PRESSURE CASTING MECHANISM.

In the words of the patent, "the effectiveness of the above-described method and apparatus for the formation of extremely light and sharp castings having a solidity, homogeneousness and a freedom from blow holes comparable to electro deposited or to rolled metal, is largely attributable to (1) the absolute isolation of the molten mass from metallic surfaces; (2) the disconnection of the molten mass from the molds until the instant of inflow; (3) the effective removal of air, vapor and gases from the matrix spaces and the pores of the molds prior to and during the inflow by communication with a large and continuously exhausted vacuum chamber; (4) the complete hermetical sealing in of the molten metal from the instant of the application of the forcing piston."

One of the most remarkable features of some of the castings is what is known as "undercutting," which is produced in the casting directly from the pattern without the use of cores. In this case the pattern is, of course, not made of metal, as it could not be drawn from the mold, but is of a plastic material like rubber, the composition of which is kept secret. The mixture of materials of which the mold is made is also not made known.

In the use of this process with patterns that have draft and may be drawn from the mold, as in ordinary sand castings, the patterns may be of any metal or other suitable material. The mold in this case may be made of clay of proper constitution, and after ramming in the ordinary way, as in sand molding, it is subjected to pressure in a screw or hydraulic press, so that the material is forced into the finest lines of the pattern. The mold is then taken out of the flask like a pressed brick, dried and baked. The baked pattern is quite porous. Another way of making the molds, which is used for very light and fine work, and also for all undercut work, is to make them of a composition which has plaster of Paris as one of its ingredients. This is poured in a liquid form into the flask containing the pattern, and allowed to set to a certain consistency, when the pattern is withdrawn, and the mold removed from the flask is dried and baked.

The molds as made by either process are in the shape of flat or thin bricks with square edges, so that they may be piled one on top of the other. When so piled the gates of each lead into a central sprue made by a hole through each mold.

THE LOCOMOTIVE PROBLEM.

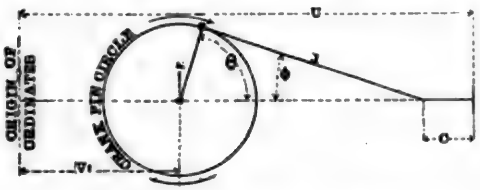
BY C. H. LINDENBERGER, C.E., DETROIT, MICH.

LET it be supposed that the stroke of the pistons of a locomotive is 2 ft., the diameter of the driving-wheels 8 ft. and the velocity 60 miles per hour: what is the maximum and minimum velocity of the piston relatively to the earth and not with regard to the locomotive, and when does each occur?

The following is proposed as a solution:

The velocity is a maximum or minimum when acceleration ceases. The latter is either positive or negative. By a negative acceleration is meant the effect of a force that would cause a body to move in the opposite direction if it was at rest.

Let r = radius of the crank-pin.
Let l = length of connecting-rod.
Let t = the time the center of the driving-wheel has moved from a fixed point on the line of railway.
Let u = the distance of this fixed point from the piston.
Let c = the distance of the piston from the cross-head, which is constant.
Let V = velocity of the engine, which is supposed constant.
Let v = velocity of the crank-pin about the center of the driving-wheel. This, of course, is constant, since V is constant.
Let θ be the angle made with the horizontal by the radius r.
Let ϕ be the angle made with the horizontal by the connecting-rod. The angle θ is measured in the usual manner, but the angle ϕ is measured in the opposite way. It follows that $\cos.\ \phi$ is always positive, but $\sin.\ \phi$ has the same sign as $\sin.\ \theta$.



For simplicity, the axis of the piston is supposed to be in a horizontal plane with the center of the driving-wheel.

From these definitions

$$u = Vt + r\cos.\ \theta + l\cos.\ \phi + c,$$

and differentiating

$$\frac{du}{dt} = \text{velocity of piston} = V - r\sin.\ \theta\frac{d\theta}{dt} - l\sin.\ \phi\frac{d\phi}{dt}$$

Now $\frac{r\,d\theta}{dt} = -v$. The negative sign shows that the driving-wheel turns in such a direction as to decrease θ.

$$r\sin.\ \theta = l\sin.\ \phi,$$

whence
$$r\cos.\ \theta\frac{d\theta}{dt} = -v\cos.\ \theta = l\cos.\ \phi\frac{d\phi}{dt}$$

$$\frac{l\,d\phi}{dt} = -\frac{v\cos.\ \theta}{\cos.\ \phi},$$

and therefore

$$\frac{du}{dt} = V + v\left\{\sin.\ \theta + \frac{\cos.\ \theta\sin.\ \phi}{\cos.\ \phi}\right\}$$

$$= V + v\frac{\sin.\ (\theta+\phi)}{\cos.\ \phi}. \qquad (1)$$

The force causing acceleration is proportional to (weight) $\times\frac{d^2u}{dt^2}$, and the velocity is a maximum or minimum when acceleration ceases, and, therefore, when $\frac{d^2u}{dt^2} = o$.

Hence, differentiating again,

$$\frac{d^2u}{dt^2} = o = v\left\{\frac{\cos.\ (\theta+\phi)\cos.\ \phi\left(\frac{d\theta}{dt}+\frac{d\phi}{dt}\right)-\left(-\sin.\ \phi\right)\frac{d\phi}{dt}\sin.\ (\theta+\phi)}{\cos.^2\phi}\right\}$$

$$= v\left\{\frac{\left(\cos.\ (\theta+\phi)\cos.\ \phi+\sin.\ (\theta+\phi)\sin.\ \phi\right)\frac{d\phi}{dt}+\cos.\ \phi\cos.\ (\theta\times\phi)\frac{d\theta}{dt}}{\cos.^2\phi}\right\}$$

$$= v\left\{\frac{\cos.\ \theta\frac{d\phi}{dt}+\cos.\ \phi\cos.\ (\theta+\phi)\frac{d\theta}{dt}}{\cos.^2\phi}\right\}$$

$$\left(\text{since } \cos.\ (\theta+\phi)\cos.\ \phi + \sin.\ (\theta+\phi)\sin.\ \phi = \cos.\ (\theta+\phi-\phi) = \cos.\ \theta\right)$$

Substituting the value of $\frac{d\theta}{dt}, \frac{d\phi}{dt}$ and dividing out common factors, we finally obtain

$$\frac{r}{l}\cos.^2\theta + \cos.^2\phi\cos.\ (\theta+\phi) = o.$$

Now, for convenience, put

$$x = \sin.^2\theta \qquad \frac{r}{l} = A \qquad \text{whence } \sin.\ \phi = A\sqrt{x},$$

and this becomes

$$A(1-x) + (1-A^2x)\left(\left(\sqrt{1-x}\right)\left(\sqrt{1-A^2x}\right) - Ax\right) = o,$$

and after transposing, squaring, reducing, and cancelling, we get the equation,

$$A^4x^3 - A^2x^2 - x + 1 = o.$$

This equation has three real roots; but the only one that is applicable here is the one that is positive, and not greater than unity. It must be noted that the radical sign is ambiguous, so that we will have $\sin.\ \theta = \pm\sqrt{x}$.

The most convenient method of finding the roots is the trigonometrical formula given in Hymer's "Theory of Equations."

After making the proper reductions and transformations, the following is found to be the solution:

Let
$$3\delta = \cos.^{-1}\left(\frac{11-27A^2}{16}\right)$$

then the three roots are as follows:

$$\left(\cos.\ \delta + \tfrac{1}{4}\right)\frac{4}{3A^2}$$

$$\left(-\cos.\ \left(\frac{\pi}{3}+\delta\right)+\tfrac{1}{4}\right)\frac{4}{3A^2}$$

$$\left(-\cos.\ \left(\frac{\pi}{3}-\delta\right)+\tfrac{1}{4}\right)\frac{4}{3A^2}$$

Where π = the length of a semicircle to radius unity, the second of these roots is usually the one we want.

As an illustration, let us suppose that $\frac{r}{l} = \frac{1}{3}$, and the root we want is, therefore,

$$\left(-\cos.\ (60^\circ+20^\circ)+\tfrac{1}{4}\right)\frac{4}{3\times\frac{1}{9}} = 0.9162$$

$$\sin.\ \theta = \sqrt{0.9162} = \pm\ 0.95718.$$

This is the *sine* of 73° 10′ 22″ nearly.

When the crank-pin radius and connecting-rod are at right angles to each other $\sin.\ \theta = \frac{l}{\sqrt{r^2+l^2}} = \frac{3}{\sqrt{10}}\ 0.9486 =$ *sine* of 71° 33′ 55″ nearly.

So that the maximum and minimum velocity is not for these parts at right angles, as some solutions assume, but is very near that place.

The position of maximum and minimum is deduced as follows: We have seen that $\cos.\ \phi$ is always positive, and that $\sin.\ \phi$ has the same sign as $\sin.\ \theta$.

In equation 1 the coefficient of v is

$$\sin.\ \theta + \frac{\cos.\ \theta\sin.\ \phi}{\cos.\ \phi} = \sin.\ \theta\left(\frac{1+\frac{r}{l}\cos.\ \theta}{\cos.\ \phi}\right)$$

and this will have its greatest numerical value when this is a sum instead of a difference.

Its maximum value will therefore be when it is a positive sum and its minimum when it is a negative sum. This will be in the first and fourth quadrants respectively of the circle.

The position for maximum velocity is $\theta = 73° 10' 22''$, and for minimum is $\theta = 360° - (73° 10' 22'') = 286° 49' 38''$.

The coefficient of v in eq. (1) is easily computed, and is found to be 1.05464.

The velocity of the circumference of the driving-wheel is about its center the same as that of the locomotive in space.

This is evident from the fact that it is the same as if the center of the wheel was fixed and the track moved with the required velocity. The velocity of the crank pin is two-sevenths of this, since that is the ratio of the diameters of the circles respectively.

Hence the velocity of the piston in miles per hour is

$$\text{Maximum} = 60\left(1 + \frac{2}{7}(1.05464)\right) = 78.07956$$

$$\text{Minimum} = 60\left(1 - \frac{2}{7}(1.05464)\right) = 41.92044$$

For the crank-pin radius and connecting-rod at right angles the coefficient of v is 1.0540926, and the great and small velocities are found to be 78.07016 and 41.92984 respectively. Hence the former is not a maximum nor is the latter a minimum, though they are very nearly so.

Any other ratio of crank-pin radius to connecting-rod may be solved in like manner.

RESISTANCE OF METALS TO SHEAR.

By H. V. Loss, M.E.

(*Continued from page 144.*)

b. Point of Maximum Resistance.

As previously mentioned, an assertion is often being made that this point exists at a penetration

$$d_1 = \tfrac{1}{3}t,$$

where t = thickness of bar. After measuring up the cards for steel bars and flat knives, we find that rupture occurs at $\frac{5}{16}$ thickness, varying of course a little on either side of this figure. In the same manner we find with 4° knife the penetration to be $\frac{1}{4}$ thickness. For 8° no average relation can be given, as the variation is very considerable, being $\frac{1}{6}$ thickness for $\frac{3}{4}$ in. bars and $\frac{1}{3}$ thickness for $2\frac{1}{4}$ in. bars, an increase of 100 per cent.

The examined results seem to justify an entire disregard for the width of the bar, the penetration apparently depending mainly on its thickness. The following table gives the average results for steel bars with different thicknesses and bevels.

TABLE NO. 2.

Thickness.	Depth of Penetration at Maximum Resistance.		
	Flat.	4 Degrees.	8 Degrees.
2¼"	......	......	.6"
1⅞"	.65"	......	.4"
1¾"	.63" to .65"	.43"	.37"
1⅝"	......	......	.35"
1½"	.44" to .45"	.4"	.25"
1⅜"	.43"	......	.2"
1¼"	......	.3"	.17"
1⅛"	.37"	......	......
⅞"	......	.2"	.13"
¾"	.25" to .27"	.2"	......

As a general result we may determine the point of maximum resistance for soft steel bars from the following formulas:

$$\left.\begin{aligned} d_1 &= .16\sqrt{t^3} \text{ for } 8° \text{ top knife} \\ d_1 &= .25\ t \text{ '' } 4° \text{ '' '' } \\ d_1 &= .3\ \ t \text{ '' } 0° \text{ '' '' or flat} \end{aligned}\right\} (1)$$

For iron we find with 8° bevel

$$d_1 = \tfrac{1}{5}t \text{ to } \tfrac{1}{4}t,$$

with a variation in thickness from 1 in. to 2 in. The experiments on iron were less numerous than on steel, and the relation was therefore in this case not as accurately established.

So far none of the derived results have coincided with $d_1 = \frac{1}{3}t$.* Whether this expression is true with regard to flat knives on iron—the only possible case that still remains—was not determined.

c. Point of Final Rupture.

When the maximum resistance has been reached the first detailed rupture occurs. With a flat knife this first distortion is shown on the broken cross section by the well-known features of detailed shear, which characteristics especially are familiar with punching—namely, as an apparent overlapping of material, as if the punch, which, of course, is nothing more or less than a flat shear, had dragged parts of the metal with it in its descent. With a beveled knife the result is somewhat different. The first rupture in this case, as marked by the point of maximum resistance, is generally followed by a break through the entire thickness, starting at the edge and penetrating a certain distance inward, generally from 1 to $1\frac{1}{4}$ in. After the knife has once more proceeded a certain distance downward, the bar is completely severed, and the question may properly be asked: What is this certain distance, as compared to thickness and width when the final rupture does occur? The correct answer must naturally depend upon the dimensions of the bar as well as the angle of knives. Again, examining the original cards, the results hereof is contained in the following tables Nos. 3, 4 and 5. The figures given represent the *total penetration*, or from the time the top knife touched the bar until it broke.

TABLE NO. 3.

Width of Bar.	Thickness of Bars in Inches—8 Degrees Bevel of Knife.													
	⅞"	1"	1 1/16"	1⅛"	1¼"	1 5/16"	1⅜"	1½"	1 9/16"	1⅝"	1¾"	1⅞"	2"	2¼"
4"	.5"	....	.55"	....	....	....	....	....	....	.7"	.75"	....	....	....
5"	....	.65"	....	....	.7"	....	....	....	....	.8"	.8"	....	....	....
6"	.7"	....	....	....	....	....	.8"	....	.9"	....	1.00"	1.1"	....	1.15"
7"		....	....	....	....	1.00"	....	....	....	....	....	....	1.3"	....
8"	....	....	....	....	....	....	....	1.12"	....	....	1.3"	1.3"	....	....

TABLE NO. 4.

Width of Bar.	Thickness of Bars in Inches—4 Degrees Bevel of Knife.					
	¾"	⅞"	1 1/16"	1¼"	1½"	1¾"
4"	....	.3"	.44"	....	....	.53"
5"	.37"	......	....	.52"	....	....
8"	....	......	....	....	.7"	....

TABLE NO. 5.

Width of Bars.	Thickness of Bars in Inches—Flat Knives.						
	¾"	1 1/16"	1⅛"	1 3/16"	1⅜"	1½"	1¾"
4"	......	.4"	....	......	......	.5"	.63"
5"	.31"	......	.47"	......	.5"	......	......
6"	......	......	......	.5"	......	.6"	.7"

For flat bars the stroke may be said to vary from .33 to .4 of the thickness, while a beveled knife has a still greater variation. It will be found, however, that formula (2) gives the stroke or penetration with fair precision for bevels up to 8° and bars up to 8 in. in width. It is possible the range may be still greater, but the writer has had no opportunity for testing it.

If s = stroke and a = bevel of top knife, we have

$$s = \frac{4}{9}\left(\sqrt[3]{t^2} + w \tan a\right) \qquad (2)$$

For a flat knife, with $a = 0$, we should then have

$$s = \frac{4}{9}\sqrt[3]{t^2} \qquad (3)$$

* In practice the value of d_1 is always divided equally between the top and bottom knives, the penetration of each knife always being $\frac{d_1}{2}$.

While the above formulas are, strictly speaking, based on steel with a tensile strength of 65,000 to 75,000 lbs. per square inch, a limited number of experiments on 5-in. iron bars with 8° beveled knife show results that do not vary considerably from those already obtained on the same dimensions in steel, as indicated by table No. 6.

TABLE NO. 6.
Iron Bars—8 Degrees Bevel.

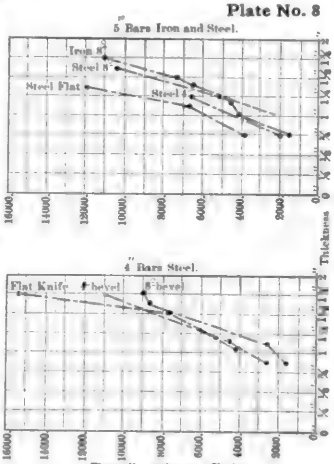
Bars.*	8°
5" × 1"	.5"
5" × 1⅛"	.65"
5" × 1⅜"	.78"
5" × 1½"	.8"
5" × 1¾"	.9"

d. Energy Consumed.*

A vital question in connection with the present investigation is the number of foot-pounds necessary to sever any one bar of given dimensions with a knife of known bevel. That there should be a difference between iron and steel in this respect is to be supposed, although some of the results derived were not at all anticipated in their character. In designing a shear it is not only necessary to know the momentary maximum exertion, which mostly determines the strength of the machine, but if not driven by water, as a common hydraulic shear, an engine or a fly-wheel and pulley has to be attached, in which case *the energy* of the cut to be made will decide the size of the steam cylinder and fly-wheels.

Plate No. 8 gives the energy expended on 4 and 5-in. bars with thicknesses up to 1¾ in. In a general way it is shown very conclusively that the flatter knife requires the greatest energy. It might have been supposed with some degree of probability that the reverse condition would exist, as a more sudden break, while showing a higher momentary maximum resistance, might nevertheless represent a smaller energy due to the decreased penetration before rupture occurs. However, such was not the case, as clearly demonstrated on all cards.

Plate No. 8



These dimensions are Ft. lbs.
Energy Cards for 4 inch & 5 inch bars.
Iron and Steel.

The 5 in. iron bar requires but very little less energy as compared to the steel bar of same dimensions, both being cut with an 8° knife. This is a condition similar to the one existing on the pressure cards of the same sections.

Plate No. 9 shows the energy for 6, 7, and 8-in. bars with results very similar to the ones already considered. The most complete series of experiments was made on the 6-in. bars with 8° knife. The plotted results show here very plainly the quickened increase in energy required as the thicknesses become greater. In this respect the energy and pressure seem both to follow a somewhat similar law, possibly a conic section.

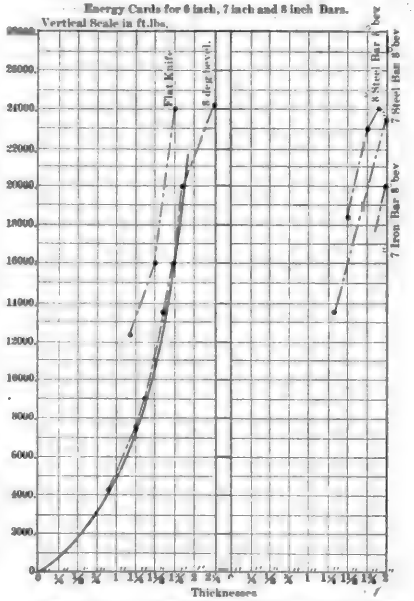
Plate No. 11 shows the energy per inch of width of steel bars with different thicknesses, giving the average results for each thickness on different widths. While maximum pressures, when taken under similar conditions as shown on plate No. 10, vary directly as the thickness, the energies seem to follow a different law, as indicated by the average line being a curve. There is no reason why iron bars under the same conditions should follow a different law, and the results on 5-in. bars will form a guide as to the proper difference to allow for the two materials.

* As with the value of d_1, in determining the point of maximum resistance, so is also here 8 divided equally between the two knives.

2. Angles.

In cutting material of this shape the relative position and construction of knives are as per sketch, fig. 2, and while the top knife is so designed as to bring it to bear first on the inside corner, this advance is so small as to practically make it a square knife. The purpose of causing the first contact to take place at the center is to prevent the angle from shifting sideways or from turning in the bottom die.

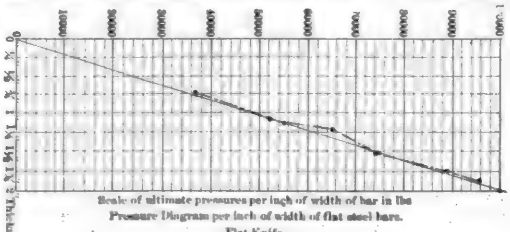
Plate No. 9



6 inch. Bar Steel. 7 inch Bar Iron and Steel. 8 inch. Bar Steel.

a. Ultimate Pressures.

Plate No. 12 shows the pressure per inch of width necessary to cut iron or steel angles of different thicknesses. By an inch of width is understood an inch of that figure which is represented by the sum of the two nominal dimensions of its legs. A 3½ × 7 in. angle has, therefore, a total nominal width of 10½ in., which latter figure, when multiplied by the value, as found on the table to correspond to any given thickness, furnishes the total amount of breaking force in pounds for that dimension. The experiments show some irregularities for iron with ⅜ and $\frac{7}{16}$ in. thicknesses, while the other dimensions, however, give fair results. One of these is, nevertheless, somewhat unexpected—namely, while the experiments



Scale of ultimate pressures per inch of width of bar in the Pressure Diagram per inch of width of flat steel bars.
Flat Knife.

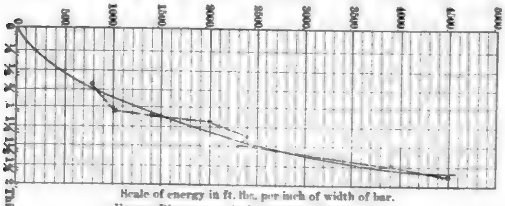
Plate No. 10

on rectangular bars with square knives clearly result in a constant ratio between power and thickness, as shown per inch of width on table No. 10, the plotted results seem in this case to indicate a ratio that is decreasing with the thickness of legs. It would appear that the peculiar cutting action of an angle knife would be responsible for this result.

b. Energy Consumed.

Plate No. 13 shows the energies expended for an inch of width with different thicknesses.

Here is another rather unexpected result demonstrated. *Iron angles require more energy than the corresponding sizes in steel.* In the neighborhood of ¼ in. in thickness this difference seems to be a maximum, decreasing as the thicknesses are increasing, and it would appear as if all difference would cease at about 1 in. in thickness, after which limit the conditions



Scale of energy in ft. lbs. per inch of width of bar.
Energy Diagram per inch of width of flat steel bars.
Flat Knife.

Plate No. 11

will probably be reversed, the steel requiring the larger energy of the two materials. That the difference will be a maximum at about ¼ in. in thickness is to be supposed, as it must be remembered that the lines on the diagram of this plate representing either or both materials must terminate and meet at the zero mark.

Pressure Diagram
For Iron and Steel Angles.

Plate No. 12

6 x 6 x ⅝ Iron Angle 6 x 6 x ⅝ Steel Angle
Types of Iron and Steel Cards
The violent break of steel angle is shown by the action of ind. perc.
Scale of lbs. for ultimate press. pr. inch of width of angle

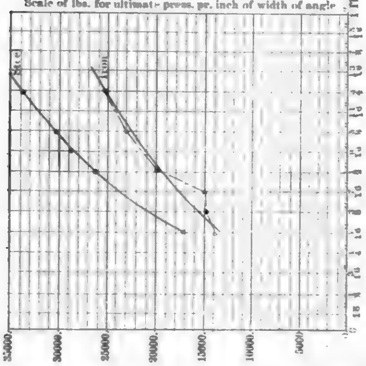
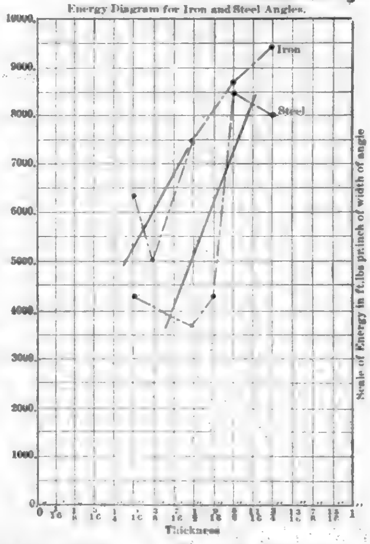


Plate No. 13

Energy Diagram for Iron and Steel Angles.



The explanation will be found by looking at the indicator cards on plate No. 12. While undoubtedly the ordinate representing the pressure is invariably larger for steel angles than for iron of the same dimensions, the shaded area representing the work done is less because of the duration of the pressure being shorter. *Steel breaks, while iron has to be cut off.* After a certain thickness has been passed the steel is not as easily broken off, thus compelling on the part of the knife a greater penetration before rupture occurs, which greater penetration and subsequent larger duration of cut suffice in combination with the more intense pressure to effect an increased energy, equal to or greater than the one corresponding to the same dimensions in iron.

HEATED STEEL.

As previously mentioned, quite diverging opinions exist with regard to the ultimate resistance of heated and rolled materials. Some years ago it was a common practice to allow 12,000 lbs. or even more per square inch as a general estimate in cutting hot work. This figure has lately been decreased to 10,000 lbs., or even 8,000 lbs, but it has been a rather rare occurrence to hear engineers argue in favor of a still smaller coefficient. Naturally the temperature and size of the piece to be cut will mainly determine its resisting qualities, although the chemical character of the steel, the percentage of carbon especially, ought as well to make its influence felt. Hitherto, in the gradual lowering of the assumed resistance per square inch, these factors have not been duly considered, but the smaller coefficients have rather been selected as based upon isolated results, now and then brought tothe attention of the engineering profession.

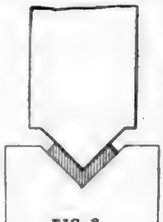


FIG. 2

As to the result of temperature, it was not within the scope of this investigation to give the decrease in strength of a bar, as it becomes heated, degree by degree. The demands of the arts, as applied to the construction of "hot shears," refer to such temperatures only which exist with the regular products as they come from the rolling-mill, and which temperatures generally vary from 1,300° to 2,000° Fahr., depending mainly on the cross-section. The intelligent and experienced workman knows at what "heat" he can roll his material to advantage, and while such temperatures are not all constant, their variation is nevertheless inside the limits already mentioned.

The knives on a hot shear are square, having neither bevel nor clearance. As the sections to be cut are generally large, no benefit would be derived from tapered blades; on the contrary, from practical reasons, such forms might be detrimental, as the increased sharpness of the edges would in all probability shorten the life of the knives.

In considering hot metal the writer has reintroduced the term, "resistance per square inch," not because he considers it eminently fitting and correct, but because of being in want of any better basis. When used in connection with the general dimensions of the bloom or billet, the resistance per square inch becomes a useful estimate.

The steel considered was:

1. Structural steel with carbon of about 20 per cent. Tensile strength in cold condition was 70,000 lbs. per square inch on 8 in. long specimen.
2. Axle steel with 30 per cent. carbon and 80,000 lbs. tensile strength when cold.
3. Spring steel with 1 per cent. carbon and a tensile strength of 130,000 lbs. per square inch when cold.

The difference in behavior between two blooms of the same cross-dimensions, one being made from structural steel and the other from axle steel, was imperceptible. Whatever be its amount, it is inside the limit of variation for any one material.

The cards from axle steel are, therefore, omitted on the plates as being unnecessary.

The spring steel, however, showed a considerable increase in resistance and energy, especially the former, as will be observed from the plates.

Plate No. 14 shows cards from a 9¼ in. by 8¼ in. bloom. Nos. 1 and 2 are taken from a bloom with a somewhat high temperature, resulting in a small ultimate resistance per square inch. Nos. 3 and 4 represent a lower temperature with higher resistance. No. 3 was the cut of the "crop end," this part of the bloom being naturally colder than the rest, hence its high ultimate.

The irregularities on the periphery of most cards, especially on the larger sizes, are due to the want of uniformity in action of the pumping plant, this being simply a common duplex pump without accumulator. It would appear from plate No. 14 that the resistance per square inch on a bloom of 80 sq. in., distributed to form nearly a square, is anywhere from 4,500 lbs. to 7,500 lbs., while the energy per square inch varies from 540 to 725 ft.-lbs. It must be remarked that in all tests with blooms or billets that were not square, the smaller dimension was invariably the one that was considered as depth when cutting.

Plate No. 15 shows the effects of the cooling of the bloom upon its resistance. Cards Nos. 1, 2, and 3 were all taken at different points of the two pieces, three cards on each dimen-

sion. The gradual increase in resistance, as time permitted cooling, is clearly shown.

With 36 sq. in. it appears that a square bloom offers a resistance of 9,000 lbs. to 11,000 lbs. per square inch.

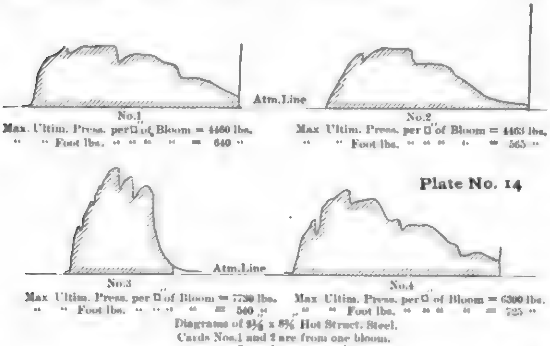


Plate No. 14

A 5 in. × 7 in. bloom, the cards of which are not shown on the plates, showed similar values.

On a 4 in. × 6½ in. billet the effect of the cooling action upon the resistance is found to exceed 100 per cent., giving figures varying from 7,200 lbs. to 15,300 lbs. per square inch.

The energy required per square inch does not seem to be much greater than what is necessary for a 6 in. × 6 in. bloom.

Plate No. 15

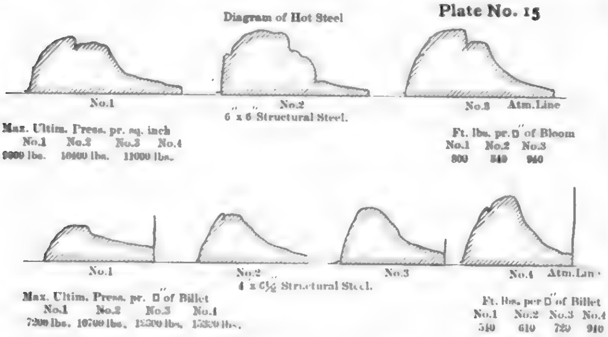
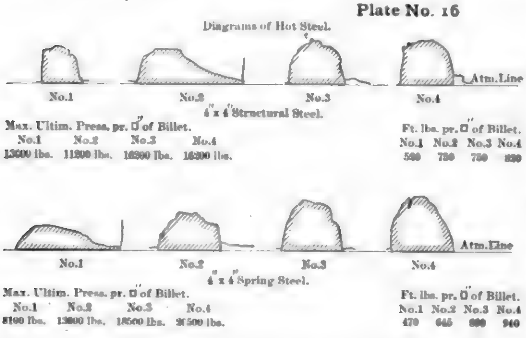


Plate No. 16 shows the difference in ultimate resistance between spring steel and structural steel to be about 25 per cent., using the maximum values in both cases. The difference in energy is very much less, being about 14 per cent.

As a general result, it will be seen *that the resistance per square inch for hot rolled steel of rectangular or square cross-sec-*

Plate No. 16



tions varies from 4,400 lbs. to 20,500 lbs., depending partly upon its hardness and partly upon the size of its cross-area, which latter element indirectly but greatly indicates the temperature, as the smaller dimensions require a considerably longer time to reduce them down to size, which time again means loss of heat.

It is not probable that the resistance in practice can be brought very much below the lowest figure here given—viz., 4,400 lbs. per square inch—as a decrease of 1,000 lbs. will henceforth mean a considerable increase in cross-section and temperature.

(TO BE CONTINUED.)

THE SMOKELESS COMBUSTION OF COAL.

According to reports that have just reached us from Germany, the difficulty of burning coal without the production of smoke seems to have been completely accomplished, and the experiments leading to this result have excited a wide interest among several large industrial enterprises, including with others the North German Lloyd, the Hamburg American Packet Company, while the Vulcan Forges of Stettin have adopted this new system of smokeless combustion. This system differs from all others which have been employed for the purpose up to the present time, and it has been called "the automatic and smokeless combustion of powdered coal."

The process is an exceedingly simple one; the fuel, instead of being introduced into the fire-box in the ordinary manner, is first reduced to a powder by centrifugal pulverizers of any construction. In the place of the ordinary boiler fire-box, there is a combustion chamber in the form of a closed furnace lined with fire-brick, and provided with an injector similar in construction to those used in oil-burning furnaces. This chamber has two openings: one on the center line and in the place of the usual furnace fire-door, the other on the opposite side. The orifice of the nozzle is placed in this latter hole and throws a constant stream of the fuel into the chamber. This nozzle is so located that it scatters the powder throughout the whole space of the fire-box. When this powder is once ignited, and it is very readily done by first raising the lining to a high temperature by an open fire, the combustion continues in an intense and regular manner under the action of the current of air which carries it in. This current is regulated once for all by the amount of powder required for the production of the heat led off to the boiler and the evaporation of the weight of steam demanded.

The powder is stored in a box, whence, by means of a very ingenious arrangement, the air under pressure carries it to the fire-box. It is, in fine, a system quite analogous to those fire-boxes where boilers are fired with hydrocarbons. Numerous applications and long experience has established this latter practice on the South Eastern Railway of Russia and the steam vessels of the Caspian Sea.

In the system under consideration the coal, that it may be drawn out and carried along by the steam or air under pressure, needs to be finely pulverized, and that is why such success has been attained in the use of coal that was already finely divided.

The air and fuel are therefore intimately commingled in the zone of combustion, while the air, having served as a vehicle for carrying the powder, loses the greater portion of its velocity. It can readily be seen that in this process the combustion of the fuel is complete, for each particle of coal in suspension in the fire-box is in contact with the oxygen required for its consumption, which is thus proven to be a state of affairs far less difficult of attainment than is usually imagined. Besides, tests have thoroughly demonstrated the truth of these assertions, since no trace of smoke is perceptible.

It may also be remarked that the air entering the combustion chamber may be first heated to a high temperature by utilizing the heat of the escaping gases in the stack. This air may also be mingled with a jet of steam, which decomposes into hydrogen and oxygen, the hydrogen serving by its combustion to assist in the elevation of the fire-box temperatures. By this system the admission of cold air is entirely avoided and a constant temperature can be easily obtained, since it does not depend on the ability of the fireman. In case of accident the fire can be instantly extinguished, by giving a single turn to the valve, which cuts off the supply of fuel. The injury done by forced fires to the boilers is not to be feared, and high stacks are no longer a necessity, as the fire-box is operated under a sort of forced draft.

If we can believe the published reports of the results obtained, they seem to be little short of the marvellous. The absence of smoke should be complete, and the practical operation of the system seems to present no difficulty. Electric lighting and other companies that have plants in the center of cities will find advantages in its use, upon which we have no need to insist. Even if it were less economical than the methods in vogue, the very fact of its suppression of smoke should lead to its adoption. Another advantage is the avoidance of an accumulation of ashes, necessitating a deal of work. —*L'Électricien.*

STRENGTH OF CONCRETE.

THE paper which was read before the Society of Architects by Mr. H. W. Chubb referred to the use of concrete as a material in building fire-proof structures. The specimens of concrete which Mr. Chubb mentioned as having been tested by Mr. J. J. Webster, M.I.C.E., had been specially prepared. The following table shows their composition, together with the results which were obtained :

Nature and Proportions of Materials in Concrete Briquettes.	Average Weight per Cubic Foot.	Breaking Weight Per Square Inch at 60° F.	Breaking Weight per Square Inch after Being Heated and Quenched.	Average Loss Per Cent of Original Strength after Heating and Quenching.
	Lbs.	Lbs.	Lbs.	Per cent.
Neat Portland cement	124.6	554.6	117.2	[illegible]
1 part cement, 1 part sand	120.9	448.0	93.0	80.0
1 " 3 parts sand	111.2	100.8	18.7	81.4
1 " 5 " "	109.7	74.6	15.0	79.8
1 " 4 " iron furnace slag	163.08	108.1	23.06	60.3
1 part cement, 1 part pumice-stone	64.8	94.58	38.3	59.5
1 part cement, 4 parts broken firebrick	95.04	84.4	30.5	50.9
1 part cement, 4 parts coke breeze	71.65	69.9	39.06	57.1
1 part plaster of Paris, 4 parts broken firebrick	89.6	66.8	10.3	75.0
1 part plaster of Paris, 4 parts pumice stone	55.6	57.4	3.4	94.7
1 part plaster of Paris, 2 parts furnace slag	148.0	223.3	6.9	[illegible]
1 part plaster of Paris, 2 parts broken firebrick	106.9	167.5	15.7	90.0

—*The Architect.*

PNEUMATIC TUBES ABROAD.

PNEUMATIC tubes for local transmission of telegrams are now used in the principal cities of Great Britain, says the *Engineering Magazine.* At present about 50 miles of such tubes are in operation, requiring an aggregate of 400 H. P., and transmitting a daily average of 105,000 messages (or 30,000,000 annually), more than half of these in London. The lengths of tubes vary greatly ; the average length is 630 yds.; the greatest single length in London is 3,992 yds.

The tubes are of lead, laid in cast-iron pipes, for protection, and are usually of 2¼ in. inner diameter ; some tubes of 1½ and some of 3 in. inner diameter are used. As a general rule, with the same air pressure and diameter of tube, the speed varies inversely as the length of the tube. In tubes not over a mile long the usual average speed is 25 to 30 miles an hour. The carriers are of gutta percha, covered with felt, with a buffer at the front end, and an elastic band at the back or open end to hold in the messages. An ordinary carrier weighing 2¼ oz. holds a dozen messages.

The marked success of the British pneumatic service led to the adoption of similar systems in Paris, Vienna, and Berlin. The pneumatic system of Paris was put into operation in 1866, and has grown steadily, so that to-day in Paris tubes are used almost exclusively for transmission of local telegrams and letters demanding quick delivery. A small stamped envelope, the *petit bleu,* costing 50 centimes, or 10 cents, is used for the message, which, dropped into a special post box, is delivered anywhere in Paris within an hour, often in 25 minutes.

In Vienna the "tube post" was established in March, 1875. The nine districts of the city are connected with a central station. The "tube mail" is dropped into special post boxes, collected every half hour, forwarded to the central station and distributed. Pneumatic envelopes cost 15 kreuzers (about 6 cents), ordinary letters 3 kreuzers. "Tube letters" are delivered within one hour after mailing. The Vienna system consists of a main circuit of 5.34 miles, with three branch lines ; total length, 7.2 miles.

In Berlin the Prussian postal authorities began in 1862 discussion of measures of relief for the overcrowded local telegraph system, and a pneumatic line was opened in 1865 between the central telegraph station and the Exchange building. The beginning of the present extensive "tube post" of Berlin dates from 1876, since which time it has been enlarged, until there are now over 28 miles of tube line in the city, with 38 stations.

Tube letters are to-day delivered in Berlin more quickly than telegrams at a cost equivalent to 7½ cents, and "tube post cards" at 6¼ cents. The tubes in Berlin are of wrought iron and have an inner diameter of 2.55 in. The system is operated by eight steam-engines, aggregating only 128 H. P.

WEIGHTS AND DIMENSIONS OF CERTAIN FREIGHT CARS.

MR. J. KRUTTSCHNITT, General Manager of the Southern Pacific Company, Atlantic system, has collected some data regarding the comparative weights per running foot of box and gondola cars and gun trucks, which are given in the accompanying table.

WEIGHTS AND DIMENSIONS OF CERTAIN FREIGHT CARS.

RAILROAD.	Kind of Car.	Weight Empty.	Capacity.	Total Loaded Weight.	Weight per Foot of Total Length.	Weight per Foot of Total Wheel Base.	Weight per Foot of Truck Wheel Base.	Weight per Foot of Wheel Base of two Adjacent Trucks.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Pennsylvania	Hopper bottom gondola.	23,200	60,000	83,200	2,853	3,098	8,320	4,992
E. T., V. & Ga.	"	25,000	50,000	75,000	2,459	[illegible]	7,500	4,286
Chesapeake & Ohio	"	24,000	[illegible]	84,000	2,732	[illegible]	8,400	5,509
Phila. & Reading	"	[illegible]	60,000	82,800	2,348	2,885	8,572	5,018
Pennsylvania	Gun truck	36,100	80,000	116,100	3,518	4,110	....	...
Pennsylvania	Flat car	51,800	100,000	151,090	3,779	[illegible]	...	...
Baldwin L. Works	"	24,000	70,000	94,000	2,849	3,663	10,080	5,640
Louisville & N.	Box car	28,000	60,000	88,000	2,400	[illegible]	8,653	5,074
S. Pacific	"	23,500	50,000	73,500	2,390	3,063	7,602	4,477
S. Pacific	"	27,000	50,000	77,000	2,095	2,678	7,962	4,358
Pennsylvania	"	30,000	60,000	90,000	2,400	3,849	9,000	5,088

ELECTRIC MINE RAILWAY AT BLEIBERG, IN CARINTHIA.

AT the lead mines of the Bleiberg Union, which cover a considerable extent of ground, the mineral from the different working places is brought to a main drawing shaft, the Rudolph shaft, 400 ft. deep, connected at the surface with the central dressing floor, along the adit-level in tubs containing 1,250 lbs., which, when pushed by hand for a distance of 3,000 ft., employed a force of 21 putters, making 19 journeys in the shift, in order to supply the daily output of 224 tons. The working of the dressing floor being in some danger of interruption from the disinclination of the putters to work regularly during the season of active operations, which is confined to the nine months, April to December inclusive, or 284 days, it was determined to substitute mechanical for hand traction in the adit, and, as there was 8 H. P. available at the dressing floor, it was determined to utilize it, partly for lighting and partly for hauling purposes. For the former purpose 30 incandescent and two arc lights have been provided, saving about $500 per annum upon the former cost for illumination ; while for the second an electric railway has been established in the adit.

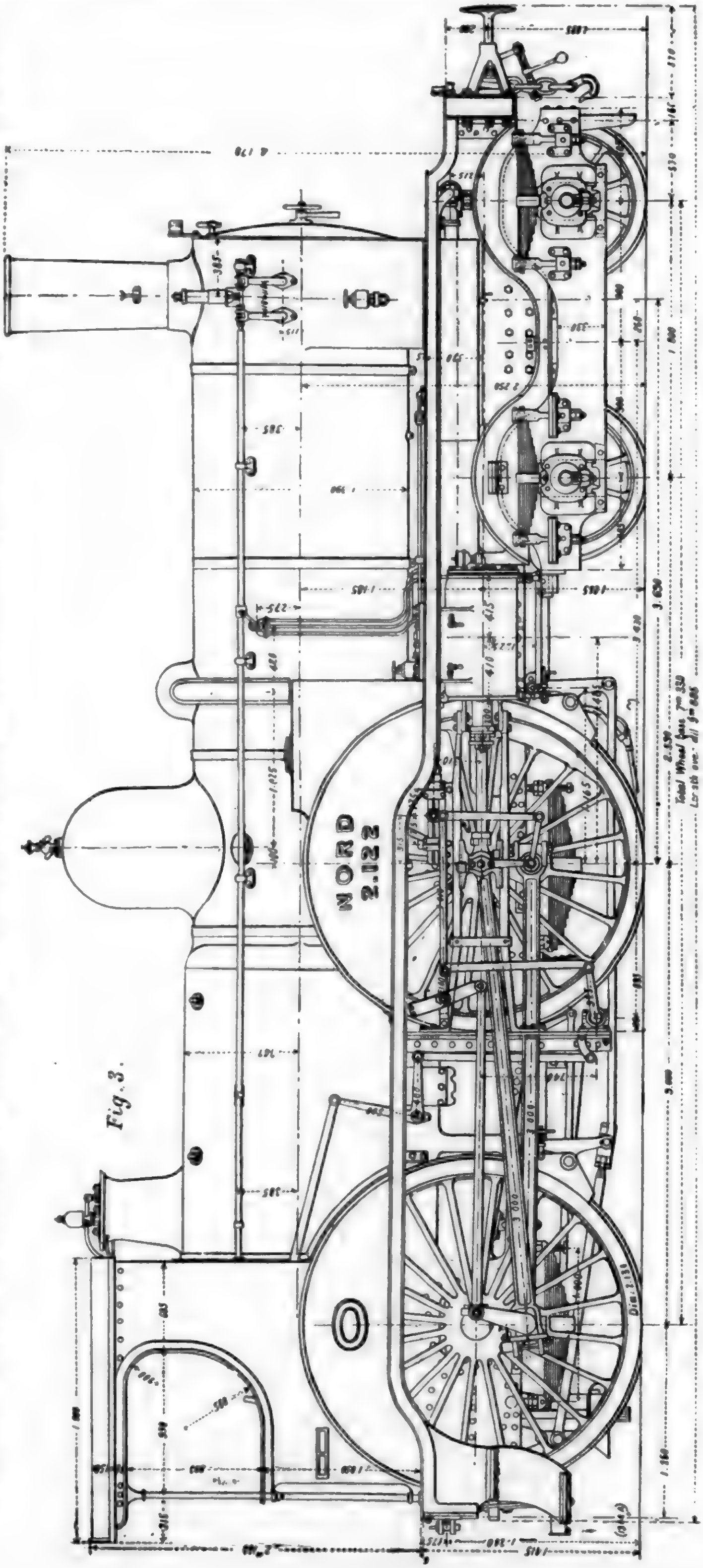
The railway is different in many respects from those previously established in collieries and other mines with large and regular levels. Both shaft and adit are very wet, rendering special care necessary in the insulation, and the latter is crooked and so narrow that the dimensions of the locomotive

are restricted in breadth to 28 in., with a gauge of 17 in., and a height of 5 ft. 8 in. from the top of the rail to the overhead conductors. The work, which is limited by the capacity of the winding engine of the shaft, consists in drawing 40 trains of five loaded tubs in the shift of 10 hours, with a mean speed of 7½ miles per hour. The tub weighs 450 lbs., the load 1,250 lbs., and the engine 3,400 lbs., giving a total weight per train of 11,770 lbs., which, on a level line with a traction coefficient of 1 per cent., requires a mechanical effort of 2.15 H. P., the corresponding electrical energy being 2.15 × 736, or 1,600 watts, or, allowing for resistance in the conductors and eight glow lamps on the road, about 2,500 watts as the normal working current, which, however, is considerably exceeded at starting. The dynamo, of compound construction, is designed for a maximum of 6,000 watts at 700 revolutions per minute, giving a current of 220 ampères and 22 volts. The engine house is 300 ft. from the shaft; the current is conveyed to the latter by two 6-mm. copper wires, and thence down to the adit by a cable with two triply insulated wires covered with lead, which is laid in a water-proofed wooden case in the footway division of the shaft, so that it may be readily accessible. The line conductors are 6-mm. wire of silicon bronze, which are supported by insulators 13 in. apart and 5 ft. 8 in. above the rails. These insulators are roofed with sheet zinc and connected by pieces of galvanized wire rope to other bracket insulators fixed to the sides of the level. This arrangement gives a double insulation, which is of some importance, as the rock, from its numerous lodes and cross courses, has a not inconsiderable conductivity. In order to divert the current at points of junction the insulated line carriers are mounted on a sliding frame, so that they can be shifted laterally from one to the other line. These points are marked by incandescent lights.

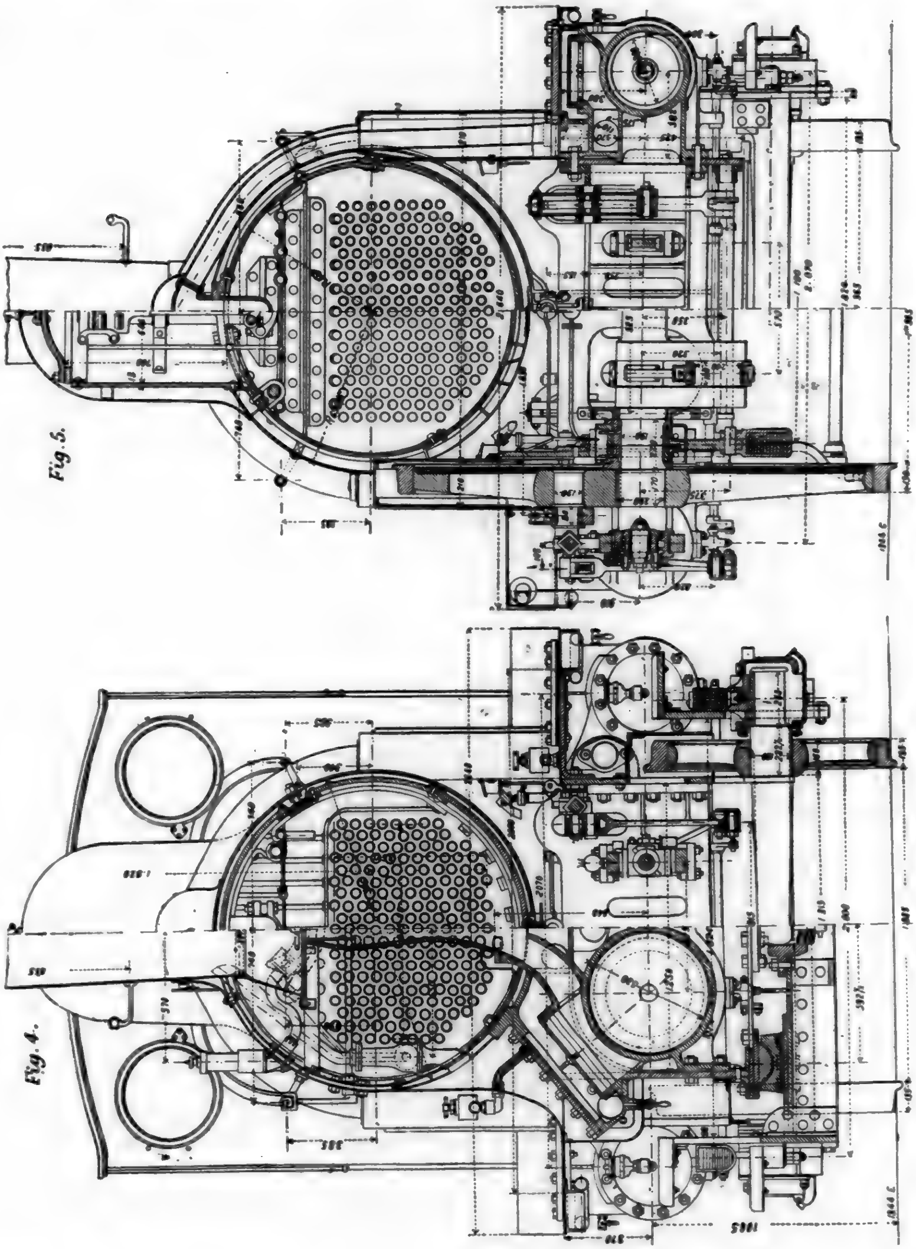
The locomotive, which is about 8 ft. total length, has two axles, 3 ft. 3 in. apart, carries a motor with a Hefner-Alteneck armature and 46-part commutator, making the same number of revolutions—700—as the primary dynamo, which is reduced by a screw and worm-wheel to 88 revolutions on the driving shaft, and to 34 revolutions on the front driving axle, by chain gearing, in order to obtain the required speed of 7½ miles per hour. The driving axle is coupled to the hinder one by a similar chain, the total adhesion weight of the engine being required for the full train of five vehicles. When only the front axle is driving, the load must be reduced to three.

The current is taken and returned by a pair of curved tubular arms, forming spring poles, with insulated iron plates at their ends upon spring carriers, which

Fig. 3.



COMPOUND EXPRESS PASSENGER LOCOMOTIVE FOR THE NORTHERN RAILWAY OF FRANCE.



COMPOUND EXPRESS PASSENGER LOCOMOTIVE FOR THE NORTHERN RAILWAY OF FRANCE.

maintain a sliding contact with the line wires. The latter have been made of silicon bronze, in preference to copper, in order to resist abrasion by the rubbing of the contact plates.

The results of the trials show the insulation to be very perfect, the loss of tension being less than was expected. The total current used, as measured at the generating dynamo, varied between 8 and 16 ampères, the meter rising to 35 ampères at the moment of starting, while in smooth running it oscillates between 8 and 12 ampères. The average energy required for working the line and the lighting of the road and the engine, including all losses in the conductor and magnetic friction, is 220 × 10 = 2,200 volt ampères, or 3 H. P., and, as the motor does 2.15 H. P. work, the efficiency is 70 per cent.

The installation, costing \$6,500, does the work of 21 putters in the level, their place being now taken by 16 fillers, at lower wages, the total saving being given at from \$1,750 to \$2,000 per annum. The advantage of lighting up the crossing points of the branch levels and the shaft bottom, which is done by pairs of 16-candle glow lamps, is also found to be of great advantage to the miners.—*Proc. Inst. C. E.*

COMPOUND EXPRESS LOCOMOTIVE FOR THE NORTHERN RAILWAY OF FRANCE.

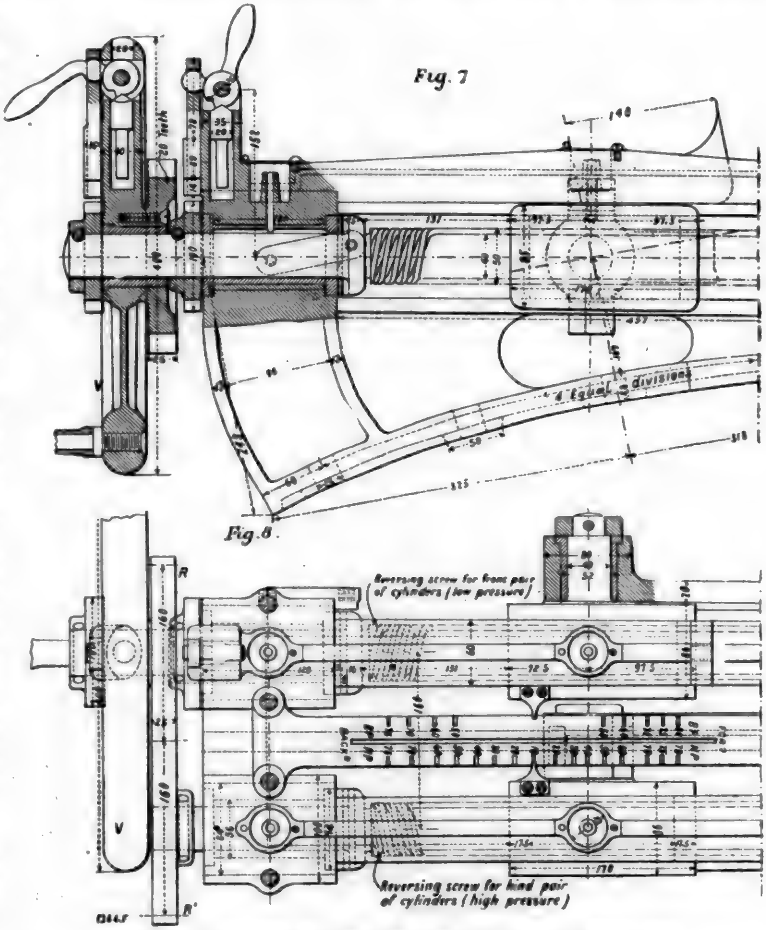
In our issue for March we published a longitudinal section of a compound express locomotive, for the Northern Railway of France, built to the designs of M. Du Bousquet, the Locomotive Superintendent of the line by the Société Alsacienne de Constructions Mécaniques, Belfort. We now publish additional engravings showing the details of the construction of the engine.

As will be seen from these views, the engine is of four-cylinder type, the high-pressure cylinders being placed outside the frames in the rear of the bogie, and the low-pressure cylinders inside the frame under the smoke-box. The steam-chests of the latter cylinders, however, are accessible from the outside, as shown in fig. 4, thus facilitating examination of the valves. The steam passes from the high-pressure cylinders to the low-pressure steam-chests through an intermediate receiver cast in one piece with the low-pressure cylinders, and common to both of them.

The engine has two pairs of coupled driving-wheels; the axle of the front pairs, which is, of course, cranked, is worked by the low-pressure cylinders, while the high-pressure cylinders drive the rear axle (which is placed behind the fire-box) by the outside cranks. The leading pair of driver-wheels is fitted with Gresham's steam sanding apparatus.

To facilitate starting, the high-pressure crank makes an angle of 162° with the low-pressure one on the same side, instead of the 180°, which would be the preferable position if the balancing of the reciprocating parts was alone considered. The consequence of this arrangement is, that in whatever position the engine stops, the port of one or the other of the four cylinders is always open for steam. This device is not, however, sufficient to insure the engine starting in all positions, as when steam is admitted into the low-pressure receiver by the valve supplied for this purpose, the back pressure produced at the same time on the high-pressure pistons may reduce the effective starting effort below what is requisite. To avoid this the three way valves, shown by figs. 9 to 12 of our engravings, have been fitted on the exhaust passages of the high-pressure cylinders. By means of these the high-pressure exhaust may be turned direct up the blast-pipe when desired. The joint between the high-pressure exhaust-pipe and each of the valves just mentioned is made by a stuffing-box having metallic packing, as shown in the engravings. This plan has been adopted with a view to lessening expansion strains. As will be seen from the views, figs. 9 and 11, the three-way valve (which is of cast iron) rotates in a cylindrical casing having three branches communicating with it, that on the left, in fig. 11, being the exhaust from the high-pressure cylinder, while that on the top communicates with the exhaust-pipe in the smoke-box. The valve is connected to a spindle which passes through a stuffing-box fitted with metallic packing, the spindles of the two valves in the opposite sides of the engine being connected by levers to the piston of a small auxiliary steam cylinder placed under the boiler, as shown in the longitudinal section of the engraving published in March. The admission of steam to and its release from this auxiliary cylinder is controlled by two cocks, shown in the side elevation, and the three-way valves can be thus readily manipulated by the driver. By the aid of the arrangement described the engine is enabled to exert at starting a tractive effort of 10 tons, the pressure of steam is in intermediate receiver, being at the time maintained at 85 lbs. per square inch.

The engine is, by the arrangement above described, capable of being worked in four different ways—viz.: 1. As a compound locomotive, as in ordinary running. 2. As two independent engines, one set being worked with steam at 200 lbs. per square inch and the other at 85 lbs. per square inch, as in starting. 3. With the two high pressure cylinders only, in the event of an accident happening to the low-pressure gear.



COMPOUND LOCOMOTIVE FOR THE NORTHERN RAILWAY OF FRANCE.

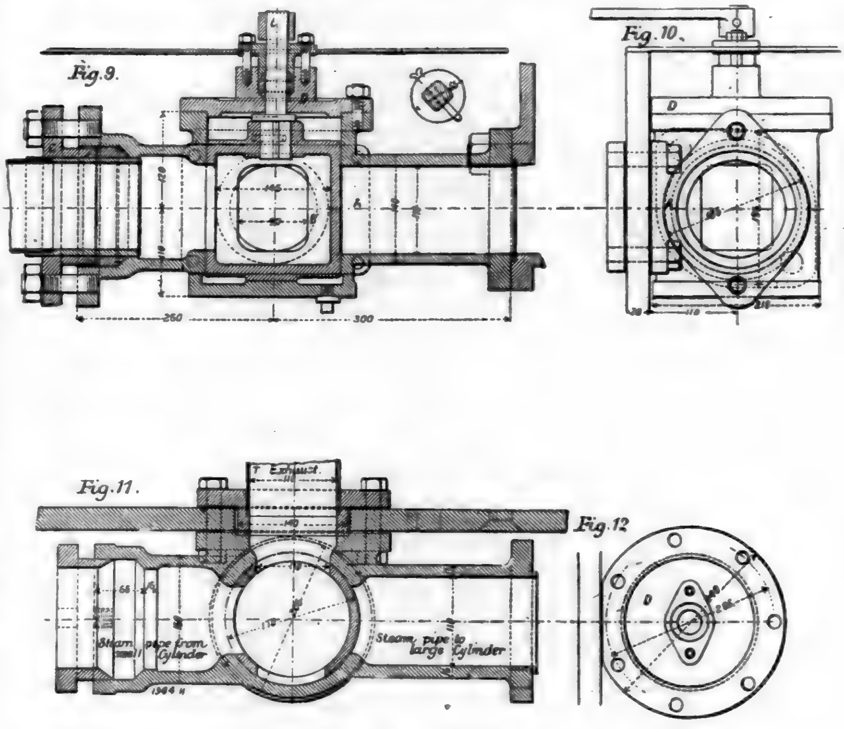
4. With the low-pressure ones only in the event of the high-pressure portion of the engine being disabled.

The boiler is designed for a pressure of 200 lbs. per square inch, and is intended to give an ample supply of steam. The fire-box of one of the engines built of this type is fitted with a Tenbrinck water bridge, as shown in the longitudinal section, while that of the second engine is provided with the usual fire-brick arch. The fire-box heating surface, exclusive of the water bridge, is 148.5 sq. ft. The barrel of the boiler is telescopic, the smallest belt being to the rear, over the low-pressure cranks, where as much room as possible is required. The dome is placed on this belt. The two safety-valves, which are of the Ramsbottom type, are placed over the fire-box. The plating of the boiler, which is of iron, is 18 mm. (0.71 in.) thick.

The valve-gear is of the Walscheart type, and can be operated independently for the two sets of cylinders. The reversing-gear, which is shown in detail by figs. 7 and 8, consists of two screw-gears placed side by side; one of these—namely, that for the low-pressure cylinders, carries the hand-wheel *V*. Firmly fixed to this hand-wheel is a pinion *R*, gearing with the second pinion *R* on the high-pressure reversing screw. The hand-wheel, however, is not keyed on its spindle, but can be fixed to it solidly when required by a catch, in which case it operates both gears when turned. On raising the catch it runs loose on its spindle, and drives the high-pressure gear only by means of the pair of pinions already mentioned. The side valves of the high-pressure cylinders were originally made with an inside clearance of 1.5 mm. (0.06 in.), with a view of reducing compression; but since indicator diagrams have been taken from the engine in actual work, it has been decided to double this amount of clearance.

The general arrangement of the engine framing will be readily seen from our engravings. The frame-plates, which are of iron, are 28 mm. (1.1 in.) thick, and, in addition to being connected in the usual way of leading trailing ends, and by the low-pressure cylinders, they are firmly braced by a steel casting inserted between the points of attachment of the high-pressure cylinders, as shown by the engraving published in March, and by the right-hand halves of the transverse section, published in this issue. The casting, which is .68 mm. (26.8 in.) long, serves to support the ends of the low-pressure crosshead guides, and also the valve links.

Heating surface of tubes	98.98 m.	1065.44 ft.
Working pressure	14 kg.	200 lbs. per sq. in
Maximum pressure in low-pressure receiver	6 kg.	85.34 " " "
Width between frames	1.25 m.	4.101 ft.
Thickness of frames	.028 m.	1.102 in.
Diameter of bogie wheels	1.04 m.	3.412 ft.
" " driving-wheels	2.114 m.	6.935 ft.
Total wheel base	7.330 m.	24.05 ft.
Diameter of high-pressure cylinders	.340 m.	13.39 in.
Distance apart from center to center	2.070 m.	6.792 ft.
Stroke	.640 m.	25.2 in.
Diameter of low-pressure cylinders	.530 m.	20.87 in.
Distance apart from center to center	.570 m.	22.45 in.
Stroke	.640 m.	25.2 in.
Ratio of volumes of cylinders		2.42.
Ratio of receiver to volume of both high-pressure cylinders		1.36.



COMPOUND LOCOMOTIVE FOR THE NORTHERN RAILWAY OF FRANCE.

The bogie, as will be seen by our engravings, has outside frames, and is not arranged for lateral displacement. The cranked axle is of the Worsdell type, with circular crank cheeks. The engine is fitted up with a vacuum-brake worked by two injectors fixed to the smoke-box. All the driving-wheels are fitted with brake-blocks, these being operated by two brake cylinders of the Hardy type, fitted to the front part of the tender. The driver's platform is well protected by a hood, and is lighted at night by a lamp in the roof. The general appearance of the engine is well shown in fig. 3.

The tender has six wheels, and can hold 14 tons of water and 4 tons of coal. It is provided with vacuum brakes acting on all six wheels. The connection between the engine and the tender is made by a rigid coupling-link and two buffers fitted with spiral springs. The principal dimensions of the engine and tender are as follows:

Length of fire-box	2.013 m.	6.604 ft.
Breadth of fire-box	1.012 m.	3.330 ft.
Grate area	2.04 sq. m.	21.96 sq. ft.
Height of fire-box in front	1.725 m.	5.659 ft.
Height of fire-box at back	1.475 m.	4.839 ft.
Mean diameter of boiler	1.26 m.	4.134 ft.
Thickness of plates	.018 m.	.708 in.
Height of center line above rails	2.242 m.	7.349 ft.
Tubes, number		202
" external diameter	.045 m.	1.77 in.
" thickness	.0025 m.	.098 m.
" length between tube plates	3.9 m.	12.78 ft.
Heating surface of fire-box	10.87 m.	117 sq. ft.
" " " water bridge	2.70 m.	29.06 ft.

	High Pressure.		Low Pressure.	
Lap of valves, outside	.054 m.	2.13 in.	.054 m.	2.13 in.
Clearance of valves, inside	.003 m.	.12 in.	.003 m.	.12 in.
Maximum tractive power working compound	7,847 kg.	7.723 tons.		
Maximum traction at starting	10,000 kg.	9.842 tons.		
Average tractive power in practice, working compound	5,070 kg.	[illegible]		
Weight of engine, empty				43.80 tons.
Weight of engine in working order				47.80 tons.
Weight on bogie				17.30 tons.
" " leading drivers				15.35 tons.
" " trailing				15.15 tons.

TENDERS.

Diameter of tender wheels	1.2475 m.	4.093 ft.
Capacity, water		14.16 tons.
" coal		4.0 tons.
Weight of tender, empty		15 tons.
Total wheel base of engine and tender coupled	13.36 m.	43.83 ft.
Length over buffers	16.44 m.	53.94 ft.

We now give details of the very complete set of tests which have been made with this locomotive. From experiments it appears that these engines get up speed very vuickly, and will easily take up a continuous gradient of 1 in 200 and 12½ miles long, either a train of 140 tons weight, exclusive of engine and tender, at a speed of 53 miles an hour, or one of 200 tons at a speed of 46½ miles per hour. The first train did the distance from Paris to Amiens (81½ miles) in 1 hour 30 minutes. The second took two hours to go from Paris to St. Quentin, a distance of 95½ miles. In both cases the speed varied very little with

TABLE I.—TIMES, SPEEDS, AND WEIGHTS OF TRAINS.

—	Train.	—	Depart.	—	Arrive.	Distance.	Speeds, Miles per Hour.					Load Tons.
							Paris Creil.	Creil Amiens.	—	—	—	
1st day. ..	15 bis	Paris.......	11.40 a.m.	Amiens	1.23 p.m.	81.2	49.7	50.3	....	....	....	110 to 150
	O "	Amiens ...	5.27 p.m.	Paris.......	7.10 "	81.2	52.8	51.0	....	....	....	110
2d "	B	Paris	10.10 a.m.	Amiens	11.56 "	81.2	47.2	49.7	....	....	....	100
	30	Amiens	3.7 p.m.	Paris.......	5.25 "	81.2	42.9	44.7	....	....	....	140
								Creil Tergnier	Tergnier Busigny	Busigny Aulnoye	Aulnoye Mons	
3d "	5 bis	Paris	8.15 a.m.	Mons.......	12.49 "	154.8	44.1	47.8	41.6	47.2	34.8	175
	48	Mons.......	7.36 p.m.	Paris.......	11.33 "	154.8	44.1	44.7	46.0	49.1	41.0	160
4th "	33 bis	Paris.......	6 20 "	Mons.......	10.46 "	154.8	46.0	47.2	42.9	47.8	37 3	145
5th "	16 "	Mons.... ..	8.36 a.m.	Paris... ...	12.33 "	154.8	42.3	47.2	45.4	46.0	37.9	115
							Paris Creil	Creil Amiens				
6th "	15	Paris	11.30 "	Amiens ...	1.13 "	81.2	49.7	50.3	....	....	....	110 to 150
	O	Amiens.....	3.58 p.m.	Paris.......	5.47 "	81.2	49.7	47.8	....	....	....	100
									Amiens Arras	Arras Douai	Douai Lille	
7th "	11	Paris....	8.0 a.m.	Lille.......	11.58 "	156.0	42.9	46.0	48.5	49.7	[illegible]	130 to 170
	46	Lille........	7.25 p.m.	Paris......	11.7 "	156.0	47.2	49.1	49.7	49.7	44.1	120 to 150
8th "	C_1	Paris.......	3.15 "	Amiens	5.5 "	81.2	46.6	46.0	....	....	....	145
"	C_2	Amiens ...	9.4 p.m.	Paris.......	10.47 "	81.2	52.8	51.0	....	....	....	145 to 200
9th "	17 bis	Paris.......	12.55 "	Amiens	3.17 "	81.2	39.1	46.0	....	....	....	145
"	O	Amiens	5.17 "	Paris.......	7.0 "	81.2	52.8	51.0	....	....	....	110
10th "			(not running)									
	Total distance run in ten days =					1743.2						
	Average per day					174.32						

profile of the line. On page 190 we show copies of 15 sets of diagrams chosen from a number taken during the trials made on March 17 and 22, 1892. They show the steam distribution in very varied conditions of working. Table II., below, shows the pull on the tender drawbar, and the results of an analysis of the diagrams with particular reference to the total indicated work, and its division between the two sets of cylinders.

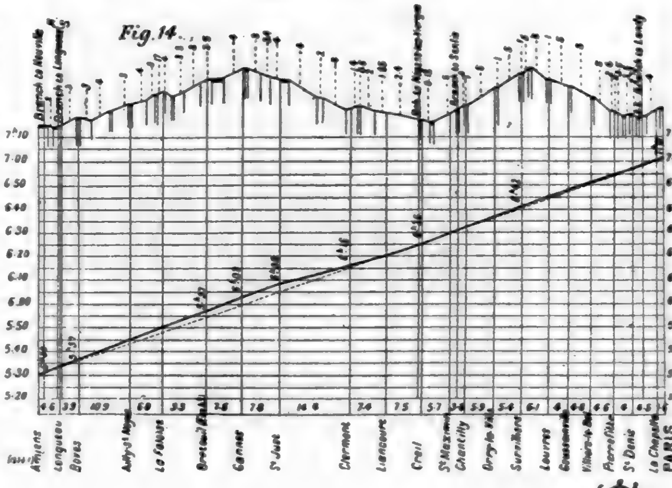
The diagrams were taken by a Deprez and Garnier indicator, which gives the curve by points, indicating exactly the pressure of the steam corresponding to definite positions of the piston. An exception should be made for Diagram 1, which was taken as the engine started, and hence at a very slow speed, and which shows a very good steam distribution. The collection, taken as a whole, shows that the steam pressure is well maintained during the period of admission. This is particularly noticeable in Diagrams 6 and 15, which, taken at high speeds, show a lower fall of pressure than is usual with locomotives in such conditions. Diagrams 9 and 10, taken with a cut-off of 45 per cent. in the low-pressure cylinders, correspond to the least fall of pressure in the intermediate receiver. The greater falls of pressure which a longer cut-off gives result in a small loss of work, but it is preferable to admit this loss rather than the much greater one which arises from excessive compression in the high-pressure cylinders, and causing, also, trouble in the running of the engine at high speeds. In this connection it should be noted that the excessive compression in the high-pressure cylinders, visible in some of the diagrams, is partly due to the fact that in these instances the back pressure has been steadily rising during the exhaust.

The dynamometer with which the pull on the drawbar was

TABLE II.—RESULTS OBTAINED FROM TRIALS OF COMPOUND LOCOMOTIVES ON NORTHERN RAILWAY OF FRANCE.

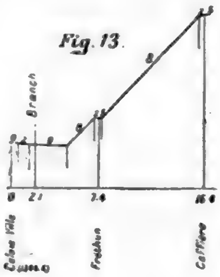
Number of Diagram.	Distance Run.	Profile of Line.	Pressure.		Cut-Off per Cent.		Speed in Miles per Hour.	Pull on Drawbar of Tender.	Work being Done on Drawbar.	Work Due to Acceleration of Engine and Tender.	Total Work being Utilized on Drawbar, taking Acceleration into Account.	Indicated Horse-Power.			Efficiency of Mechanism $\kappa = \frac{Tl\,u}{T\,m}$
			In Boiler.	In Intermediate Receiver.	High-Pressure Cylinders.	Low-Pressure Cylinders.						High-Pressure Cylinders.	Low-Pressure Cylinders.	Total $T\,m$.	
		Slope per cent.	Lb. per sq. inch.	Lb. per sq. inch.				Tons.	Tu.	T.	$Tl\,u + T$.				Per cent.
							Train 17 bis from Paris to Longeaux. March 17, 1892. Load drawn, 175.7 tons.								
1	0	....	199.1	60.5	40	50									
2	5.51	3.5 up	199.1	64.0	42	51	47.0	1.525	427.2	— 4.24	423.96	430.0	487.0	917.0	46.1
3	46.6	4.0 "	199.1	64.0	48	55	48.5	1.772	512.6	+ 9.66	522.26	474.1	539.0	1013.1	51.6
4	51 0	3.4 "	199.1	64.0	48	55	44.2	1.967	518.5	+ 11.96	530.46	358.5	537.0	895.5	59.2
5	52.8	3 0 "	199.1	64.0	44	53	47.9	1.673	478.0	+ 16 91	494.91	474.4	497.4	971.8	[illegible]
6	63.5	3.5 down	192.0	49.8	34	53	61.8	.089	258.1	0	258.10	433.9	432.0	865.9	[illegible]
							Train 17 bis from Paris to Longeaux. March 22, 1892. Load drawn, 143.7 tons.								
7	12.4	level to 3 p.c.	199.1	71.1	45	53	47.2	1.673	472.1	+ 43.1	515.7	471.7	[illegible]	1061.7	48.5
8	14.9	from 1 to 45	199.1	85.4	50	50	44.7	1.821	486.7	— 19.9	466.8	442.1	[illegible]	1040.0	44.9
9	33.5	2.4 p.c. curve of 3,250 ft.	199.1	60.5	35	45	41.6	1.427	355.0	+ 12.6	367.6	[illegible]	329.5	586.1	62.7
10	34 8	2.4 up	199.1	60.5	35	45	42.3	1.378	347.9	+ 5.0	352.9	293.1	334.4	627.5	[illegible]
11	43.8	4 "	199.1	60.5	40	51	44.7	1.614	431.4	0	431.4	[illegible]	[illegible]	776.1	55.5
12	46 5	4 "	199.1	60.5	40	51	46.0	1.575	432.5	0	432.5	[illegible]	386.8	732.2	[illegible]
13	48.5	4 "	199.1	60.5	40	51	45.7	1.526	416.3	0	416.3	435.3	469.5	[illegible]	44.2
14	53.0	3 "	199.1	67.6	40	48	43.5	1.526	[illegible]	+ 33.3	429.7	349.2	394.0	743.2	57.8
15	63.5	3.5 down.	195 5	42.7	31	51	57.2	.719	245 4	0	245.4	273.9	280.4	554.3	44.2

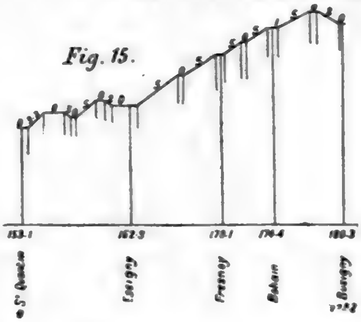
ascertained was carefully calibrated before the trials, and its indications can be relied on. The figures obtained show that the horse power at times exceeded 1,000, a result which has been obtained on all the trials without forcing the engine in any way, the water-level and pressure being maintained at their normal value; nor was any special fuel used. It will also be noted that the power is pretty evenly divided between the two sets of cylinders. Of course, as the driving axles are coupled together, there is no advantage in this so far as adhesion is concerned; but the maximum stresses on the separate parts are thereby reduced. As regards the efficiency of the mechanism, it will be noted that the pull on the drawbar has been corrected for the acceleration of the engine and tender. This is necessary, as, when the speed is increasing, the work done in imparting a higher velocity to the engine and tender would otherwise be available at the drawbar, and similarly, when the speed is decreasing, the work already stored in the engine and tender increases the pull on the drawbar.



To form a fair idea of the capabilities of the engine, such trials as the above are insufficient, for in them the engine for obvious reasons is run under as favorable conditions as possible, and hence it is necessary to ascertain what the engine can do under ordinary working conditions. During the months of February, March, and April, the engines 2121, 2122 have worked the express service (first series) from the La Chapelle station according to the speed schedule (Table I.).

In deducing the average speeds in the above schedule, the following allowances are deducted from the total time, as well as the stops: 1 minute for starting, 30 seconds for stopping, and 1 minute for each slowing at junctions, swing bridges, etc. In the above cases the engine-drivers have frequently used the great power of their engines in making up wholly, or in part, time lost at starting, or through slows or stops on the journey.





Very good results were got on the 0.8 per cent. grade shown in fig. 13, with train O of November 6, 1891. The train had 27 axles and weighed 140 tons, excluding the engine and tender. The time made was as follows:

	h.	m.
Calais Ville, departure...	2	59
Caffiers "	3	14

Hence the distance was run in 15 minutes, including the time lost by slowing at the junction shown. The speed up the 0.8 per cent. grade was about 43.5 miles per hour. Good results have also been obtained on less heavy but longer inclines, such as that shown in fig. 14. The maximum grade on this line is 0.5 per cent. The train load was 110 tons, and it will be seen from the diagram that the speed line is nearly straight, being but little affected by the inclines.

Comparing the two new engines with two older ones—viz., Nos. 2876 and 2887, which work on the same service, the returns for the months of February, March, and April show the following results:

Numbers of Engines.	Fuel. Pounds per Mile.			Oil.
	Briquettes.	Coal.	Total.	Ounces per Mile.
2121, 2122	5.055	26.962	32.017	.880
2876, 2887	6.811	30.616	37.427	.982

The coal used in these express engines consists of the following mixture:

	Per cent.
Run of mine, 25 per cent. bituminous........	50
Small bituminous coal......................	20
Small steam coal...........................	30

The figures above show, as will be seen, a saving of 14.45 per cent. with the new engines. It should, however, be noted that the total consumption as given above includes in each case the constant quantities required for lighting up and maintaining the fires at the station. To eliminate these constants, the value of which would be difficult to determine, and which are far from negligeable, trials were made of the water used by engine 2121 and engine 2863, this latter being a simple engine, with cylinders 18.11 in. in diameter, the working pressure being 156.4 lbs. per square inch. The engine was in very good condition. These engines were put to draw the same load—viz., 180 tons, at similar speeds and under identical atmospherical conditions.

The consumption, as determined on the run from Paris to St. Quentin, 95.3 miles, was as follows:

	Gallons of Water per Mile.
Engine 2893..................................	26.86
" 2121..................................	20.61

showing an economy for the latter of 23.28 per cent.

It also appears that the oil consumption of the compound was comparable to that of simple engines. The amount used was divided up as follows:

	Ounce per Mile.
14 axle-boxes (engine and tender)...........	.341
Running gear................................	.198
Cylinders and slide-valves..................	.341
Total........................	.880

The different parts are very accessible for oiling, all important parts being easily got at. Automatic lubricators are used for the cylinders and slide-valves, and the other arrangements are so effective that runs of 155 miles can be made without requiring more than a five minutes' stop for oiling up in the course of the run.

In accordance with the usual practice of the company, the fire is started with briquettes or large coal, being afterward maintained exclusively with coal of the composition given above. The fire-boxes of these engines, being deeper at the

back than those of the "Outrance" type previously built, have some advantages. When the draft is strong the coal is not carried forward, and at the end of a run, when the grate is already covered with a certain thickness of cinders and clinkers, a sufficient thickness of bright fire can still be obtained. When first put to work both engines had Tenbrinck water bridges. In consequence of leakage, this bridge on one engine was dismounted and repaired. Since then it was worked quite satisfactorily. That of engine 2121 has, however, been replaced by a firebrick bridge, and the change seems to have made no difference in the steaming qualities of the engine, but a longer experience is required to fix definitely the value of the water bridge.

The boiler is fed by two injectors of the Sellers type, the one on the left-hand side being a 7½ mm. injector, and that on the right a 9½ mm. In ordinary running the left-hand injector is kept at work nearly continuously. In spite of the high boiler pressure (200 lbs. per square inch), both these injectors have worked very well, the temperature of the water in the tender being about 122° Fahr. It is true that the lift only becomes high—viz., from 2.6 ft. to 4.26 ft., when only 2 cub. m. of water remain in the tender.

All the handles required for working the engines are arranged so as to make the handling as easy as possible. The driver has close to hand the regulator, the reversing gear, the handle regulating the exhaust from the high-pressure cylinders, that admitting steam direct to the low-pressure cylinders, and that of the Gresham sanding apparatus, together with the valves regulating the vacuum-brake. The stoker on his side finds the whistle-gear, the damper-gear, the blow-off cocks, and the blower. When the engines had run 37,000 miles, the whole of the running gear was carefully examined and found in perfect condition, a fact which shows that the cost of maintenance will be low.

In conclusion, it may be of interest to say a word on the use of coupled wheels, the plan of giving the high-pressure cylinders an alternative exhaust up the blast-pipe, and the system of independent cut-offs in the two sets of cylinders. The coupling-rods were removed from engine 2121 for some days in March, 1892, and during that time it ran, on March 3, the trains C_1, weighing 145 tons, and C_2, with 170 tons. The rail was in very good condition, but slipping occurred at every start and even sometimes on the inclines. Down grade the speed was the same as with the rods in place. In short, under these very favorable conditions no advantage was found in the running of the engine, while, on the other hand, the starting power was reduced, and, moreover, the vibration at high speeds was considerably increased, due to the fact that the relative position of the cranks was no longer maintained.

As regards the plan of providing an alternative escape up the blast-pipe for the high-pressure cylinders, this arrangement increases the starting power, the tractive effort being then capable of reaching 10 tons. It should, however, be noted that to utilize this great tractive power a coefficient of adhesion of $\frac{1}{3.5}$ would be required, which is difficult to obtain even with the Gresham sanding apparatus. By means of the special regulator with which these engines are provided, it is, however, possible to work the engines at starting at very nearly their limit of adhesion. Further, the arrangement in question has this further advantage, that, in case of breakdown, either set of cylinders can be worked independently of the other. Thus, with train 17 bis of December, 1891, the front cylinder cover of one of the low-pressure cylinders of

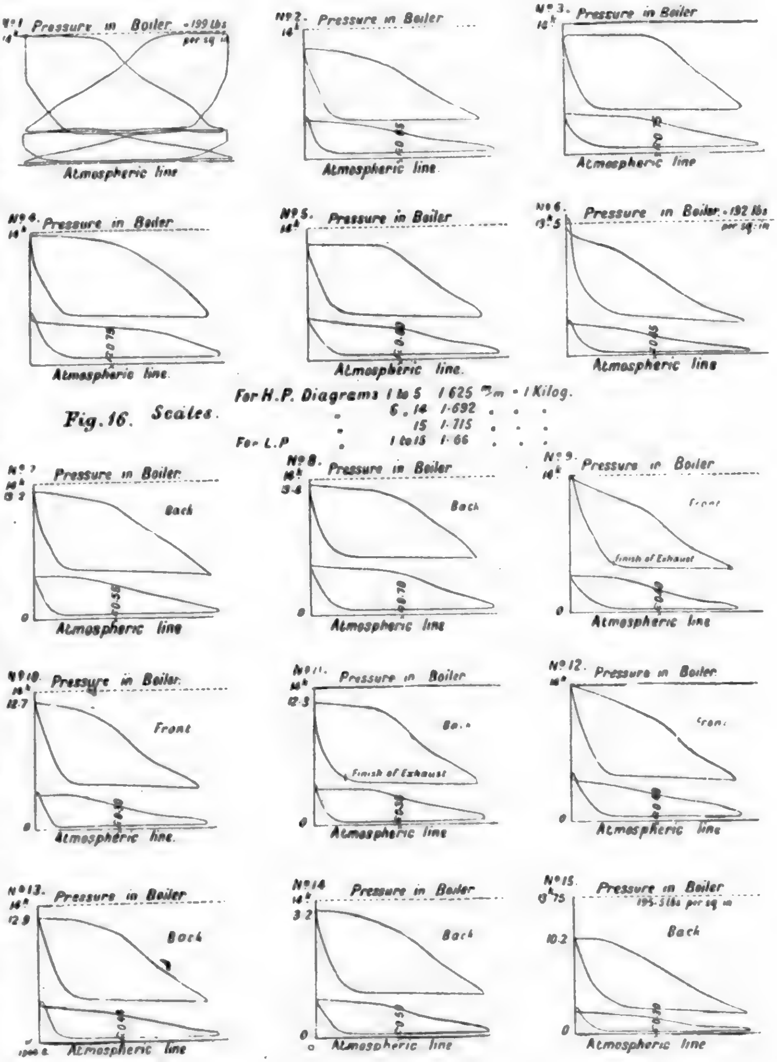


Fig. 16. Scales.

engine 2121 broke at kilometer 70 between Clermont and St. Just, but the driver took the train on to Amiens (kilometer 131) with the high-pressure cylinders only. This run of 61 kilometers (38 miles), 10½ of which were up a 0.4 per cent. grade, was done in one hour; the average running speed was 46 miles per hour, the load being 150 tons. If necessary, the engine could have taken the train beyond Amiens.

A compound engine previously built by the company—viz., No. 701, did not run down grade as well as the simple engines, but the new engines, when working compound, have attained speeds of 62 to 75 miles per hour under these condi-

tions. This easy running is partly due to the large size of the various steam-pipes, but also to the independence of the two sets of expansion gears. Experience has shown that, owing to this, the pressure in the intermediate receiver can be lowered by giving a late cut-off to the low-pressure cylinders, which facilitates the running of the engine at high speeds. The following trials were made with trains 17 bis of December 5 and 7, 1891, weighing 140 tons. On the first occasion the cut-off was made the same in the two cylinders up to kilometer 111, and then changed. On the second occasion the reverse was the case.

Date.	Load.	Regulator.	Position on Line.	Admission Per Cent. High-Pressure.	Admission Per Cent. Low-Pressure.	Pressure. Boiler.	Pressure. Intermediate Receiver.	Speed. Miles per Hour.
	Tons.		Kilom.			Lb. per sq. in.	Lb. per sq. in.	
Dec. 5	140	Half open	100 to 111	40	40	185	56.9	57.2
			116 to 117	30	50	185	85.6	62.1
			118	..	..	192	39.1	64.0
Dec. 7	140	Half open	108 to 112	35	50	192	42.7	62 1
			116	40	40	199	78.2	55.9

This independence of the expansion gears also facilitates the running of the engine with one set of cylinders in case of a breakdown.

We are indebted to *Engineering* for both the description and engravings of this engine.

THE SYSTEM OF ELECTRIC CAR LIGHTING ON THE JURA-SIMPLON RAILWAY.

After many experiments the Jura-Simplon Railway have adopted two types of lamps for use in their electric system of lighting, to wit: Lamps of 10 candle power for lighting the interior, and lamps of 5 candle power for lighting platforms and toilet-rooms. The lamps of 10 candle power are of the oblong form, those of 5 are round; they are all attached to the ceiling of the car inside of a hemispherical glass globe, such as is used for gas lighting. Fig. 1 gives a sectional view of a lantern, and shows how the incandescent lamp is attached. The heat developed by the lamp causes very rapid deterioration; they have therefore been placed under the ventilators, so that they are continually cooled by the ascending current of fresh air.

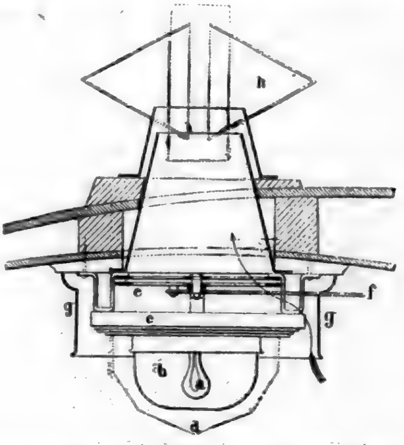


Fig. 1.

Above the lamp there is a convex reflector, which diffuses the light below it better than can be done by one of concave form. The accumulators are placed in a box beneath the floor of the car. This box is closed by a shutter which turns up vertically, and is composed of two smooth pieces of wood furnished with contact plates, which are soldered to the ends of the main wire which feeds the lamp in the car. When the tray containing the accumulators is put into this box, the two bars attached to the poles of the battery come in contact with the two strips of wood, so that the connections are automatically made. Fig. 2 gives a perspective view of a battery and accumulators in the sliding drawer. The lighting and extinction of the lamps are done by means of a switch on the main wire that is fastened to the outside of the car near the brake van. This switch can only be moved by means of a special key, which is carried by the trainmen. In each first-class compartment there is a special cut-off identical with the main cut-off and led into a branch wire from the lamp.

This cut-off permits the lamp to be put out when the apartment is unoccupied.

At first the passenger had facilities for regulating the intensity of the light for himself. This was done by placing two lamps of 5 candle power each in each compartment instead of one of 10. A special switch permitted the two lamps to be put in series, which gave faint light, or in parallel, which gave the normal light; but the trials were unsatisfactory and the method was abandoned.

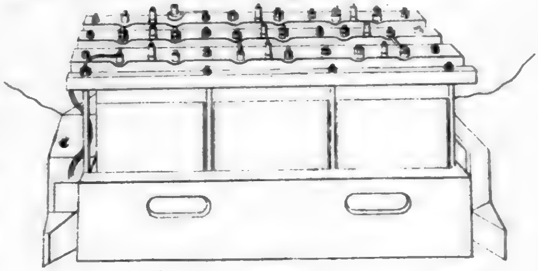


Fig. 2.

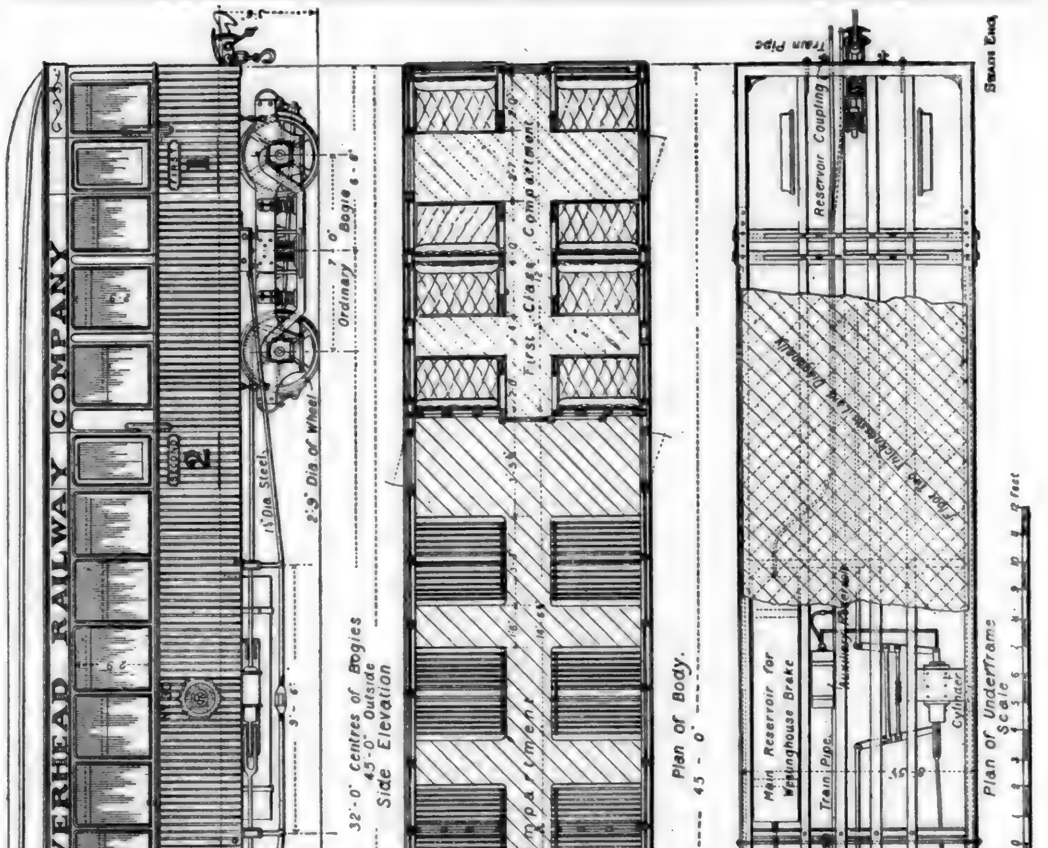
The cut-off circuit consists of simple lead plates which are placed in the feed-wires of each lamp, the general cut-off being a fusible wire placed by the side of the box which carries the battery, in order to avoid the dangers which would result from an abnormal rise in the intensity of the current. The accumulators used on the Jura-Simplon are of the Huber system. Each battery is composed of an ebonite case hermetically sealed, provided with ventilators and divided into three compartments, each inclosing an element formed of five plates. The battery contains nine elements connected in series.

The plates of each of them are formed by an unoxidizable alloy of lead and antimony. The plates are filled with the oxide of lead for the positive plate, with litharge for the negative plate. The pastilles are perforated, which permits them to expand freely toward the center without putting any strain on the lead grid; each element gives a tension of two volts. The capacity of the battery is about 120 ampère hours, or $120 \times 18 = 2{,}160$ watts hours. The maximum power of the discharge is about 5 ampères, and the normal discharge is 9.8 ampères, which corresponds to a power of about 170 watts. As the lamps used consume three watts per candle power, the intensity necessary for a difference of potential of 18 watts is .17 ampères, so that the battery can furnish 120 ampère hours = 705 candle power hours.

The normal power of the discharge of the battery being 170 watts, it can furnish lamps having a total luminous intensity of 171 watts ÷ 3 watts = 56 candle power, and the total duration of the lighting will be $\frac{705}{56} = 12.6$ hours.

The total luminous intensity of all the lamps of a car having now been brought from 30 to 35 candle power, according to the type of the car, the available duration from the battery is from 23 to 20 hours. First-class cars with three pairs of wheels running in international service are provided with lamps having a total luminous intensity of 70 candles, and these cars are also provided with two batteries of accumulators coupled up in parallel, so that the total duration of 20 hours can be obtained; the battery weighing 242 lbs. can be easily carried and put into place by two men. The weight is subdivided as follows: Case and liquid, 83.6 lbs., and plates, 158.4 lbs. The capacity of the battery being, as has been said before, 2,160 watts hours, the weight is equal to .112 lbs. per watt hour of capacity. This result is better than that which was obtained in the lighting done by the German Railway Commission at Frankford-on-the-Main.

On each box there is a notice giving the number of hours, which must not be allowed to be exceeded before the battery is recharged. There is also an electro mechanical clock which is set in motion when the lamp circuit is closed. The dial of



the clock shows the number of hours during which the accumulators have been furnishing the current. It is divided into 30 hours, and has a red pointer, which indicates the starting-point. This very simple arrangement permits the inspector to tell at a glance whether there is any necessity for recharging. Each time that it is done the clock-pointer is set at zero. The principal stations are also provided with a supply of large accumulators. These accumulators are handled at the station on a four-wheeled truck, carefully hung so that there is no danger of shocks. The tray which contains the accumulators can be placed upon the ground without any danger of short circuiting, since the contacts are some distance from the bottom.

In order to avoid all causes of loss of electricity, resulting

from contact with damp objects, as well as to prevent shocks during the transportation of the accumulators from the truck to the car, occasioned by the splashing of the liquid, a litter is used for this purpose. When the battery is replaced, after having been working for the time marked on the car, a memorandum is made of the hour marked by the pointer, and the clock-work is set back so that the pointer indicates zero. The box is closed by raising the sash, which pushes the tray of accumulators back against the back of the box by means of rubber cushions, which prevent any sudden displacement, and also take up shocks due to the motion of the car. According to the report furnished by the company, the cost of this system of electric lighting is as follows: The available capacity of a battery is 2,160 watt hours; admitting the effectiveness of 70 per cent., it will be necessary to charge it with 3,100 watts. The power at Fribourg is delivered to the shaft of the dynamo at a cost of one cent per horse power hour, admitting an effectiveness of the dynamo of 90 per cent. and of the wiring 95 per cent. The cost rises to about 1.2 cents per horse power hour. The kilowatt hour then costs about 1¾ cents per hour; the charge in the battery being 2.16 kilowatts for which the effective charge of 3.1 kilowatts is necessary, the cost of the battery is 5¾ cents.

Coming now to the first cost, it will be divided under three heads: that of the electrical energy, the maintenance of the apparatus, and labor. As for the electric energy in a car lighted by the means of six incandescent lamps, with a total intensity of 50 candle power, the amount of energy acquired would be 150 watts for an average lighting of five hours per day, or 1,825 hours per year, the energy consumed will be 273.7 kilowatt hours, and the annual cost of lighting is about $5.

Maintenance of the Apparatus.—The lamps have the durability of 600 hours, each lamp must therefore be replaced three times a year, counting upon an average lighting of five hours per day. Lamps cost 40 cents. The expense of renewing will therefore be $7.20. The company manufacturing accumulators charge $5 per year for accumulators for maintenance. At the end of five years the company agree to replace the accumulators to the Jura-Simplon Road on a basis of a depreciation in their value of 8 per cent.

As the battery costs $66, and the annual depreciation is 8 per cent. we have the annual cost for depreciation of $5.28. The general plant of Fribourg cost about $4,000. We may take 40 per cent. of this, or $1,600 as applicable to that portion of the plant which is especially adapted for charging the accumulator. We may also take $1,260 as the cost for the car and equipments, giving a total expense of $2,860. This expense being divided among 120 batteries gives $23.50, of which interest and depreciation rated at 5 per cent amount to $1.17. Finally, the car apparatus being estimated at an average cost of $50, with interest and depreciation for the same at 5 per cent., we have $2.50. The total expense for the maintenance and depreciation of the car is therefore $33.01.

The expense for labor is about the same as that for lighting with oil, or $5.40 per year. The lamps would thus have an expense of $32.40 per car per year. Adding the above, we have

Electrical energy	$5 00
Maintenance and depreciation	33.01
Labor	32 40
	$70.41

These figures show that the cost of electric lighting by means of accumulators in Switzerland is far less than the cost of their method of oil lighting, but it would be imprudent to jump to the conclusion that electricity is the most economical method of lighting; since the Swiss are in a particularly favorable situation for electric lighting, as the current is furnished at the extremely low price of one cent per horse power hour.

The conclusions reached are that electric lighting for European cars is not practical by lighting each car with its own accumulator. Each compartment should possess two lamps, so that in case one is extinguished the other can furnish the necessary light, and recourse to lighting by candles or lamps should not be permitted.

Concerning the choice of the source of electricity, it is only by experiment of long duration that the system and style of accumulators best adapted for the work can be decided upon. The very fact that improvements have been made in accumulators in the past few years show that there is still room for further advancement, both from the standpoint of their durability and resistance to vibratory shocks. Finally, it is not probable that electric car-lighting can be practically introduced, except where the company can purchase the current at very reduced rates, or where they are already provided with their own generating stations.

PASSENGER CAR OF LIVERPOOL OVERHEAD RAILWAY.

We take from *The Engineer* an illustration of the side elevation and plan of the new cars which have been recently placed upon the Liverpool Overhead Railway. These cars are run in trains of two, and are 45 ft. long over all, with a width over side pillars of 8 ft. 6 in. The carriages are mounted on two four-wheeled bogies, one of which carries a motor, as shown. The distance between wheel-center of the bogie is 7 ft., and the wheels are 2 ft. 9 in. diameter. They carry 57 passengers, 16 first-class and 41 second class. As each carriage is fitted at one end with a driver's box and necessary switch and brake-gear for controlling the work, there is no shunting at the terminal stations, the driver changing ends. The gangway between the two cars gives a clear passage through for the guard.

The engraving of the plan shows very clearly the internal arrangement of the car. The motors on each train are on the leading and trailing bogies. Six incandescent lamps light each carriage, supplied with current from the center conductor, the same as the motors.

The carriages are fitted with Westinghouse brakes, with compressed air stored in receivers carried under the carriages, and these being charged by an air-compressing plant fixed at the generating station at the north end of the line. Hand screw brakes are also provided.

The armatures of the motors are mounted direct upon the axles. Ten revolutions of the axle per minute gives a speed to a car of one mile per hour. The maximum speed necessary to do the journey in the time specified is approximately 26 miles per hour, or 260 revolutions of the motor per minute.

SOME THOUGHTS ON BOILER INSPECTION.*

By John Hickey.

The simple words "boiler inspection" may be considered as meaning but very little, or they can be regarded as encompassing a great deal.

In its simplest form, the duty of a boiler inspector may be performed by the ordinary boiler maker, who, by a hasty glance, only observes the conditions of exposed surfaces and passes rapidly all parts not showing considerable irregularity of surface or having the appearance of leaks.

On the other hand, it may be said that the proper fulfilment of boiler inspection is far reaching; that such duties should commence with the manufacture of the plate; that it should include the tests which boiler plate is necessarily subjected to; that such inspection should guide and assist in reaching designs intended to meet certain demands and requirements under well-established conditions.

The duties of inspection should establish and conduct the tests which a complete boiler is required to undergo; it should outline the character of the test power, decide how long such test should be maintained, and what to be observed during the operation. Inspection duties lead on to the boiler in service, where it must institute the most critical examination as to how the several parts are performing required duty; must direct special attention to the extent of deterioration in part or as a whole; and finally, pass on the methods pursued by persons charged with its care and management.

Briefly stated, then, boiler inspection should commence with the manufacture of the boiler plate, pass successively on its strength and endurance, on the design and construction, on the manner of conducting and treatment in testing, observe its performance in service, establish periodical testing, and institute the most intelligent methods for its care and management.

What constitutes in detail the full duty of a boiler inspector cannot be considered in a short paper; a volume could be written on this point alone. What is stated must necessarily be local and passing. Essential points only can be treated.

Inspection duties should commence with the manufacture of the plate, where alone all the circumstances connected with its quality and manufacture can be ascertained. Uniformity of thickness in each plate, homogeneousness of the metal, and exceptional freedom of lamination are features of the highest importance in boiler plate. This is especially true of fire-box plate.

Passing next to its tensile strength, which practically means a certain strain applied and constantly increased until the result produces rupture, the amount, or percentage, of elonga-

* Paper read before the Northwest Railroad Club.

tion should also be noted. This element is displayed by the metal between the load at the elastic limit and that at the limit of tensile strength. Really the elongation power of boiler plate is an important feature. It establishes the ductility of the metal and makes known its ability to adjust itself (without endangering the safety of the boiler) to the elements of expansion and contraction; and reasonably must be considered a factor in its endurance.

The limit of elasticity must also be determined and accurately established. This is the amount or extent of strain which may be applied to metal, causing it to elongate to the extreme point, where, on the removal of the strain, it returns to its original dimensions. The stress denoting the elastic limit in boiler plate should form the basis for calculating the strength of the boiler. The reason for this is obvious when it is considered that, while the elastic limit of the plate may fall far short of its ultimate capacity, the stress which caused the metal to reach this limit will, if frequently applied, soon exceed the elastic point and make way for permanent set; and a continued application of this, or perhaps a less load, will ultimately cause fracture.

Passing to the design and construction of a boiler, both of which should be under the eye and subject to the advice of the experienced inspector, at this point it may be proper to call attention to the fact that, of all other structures we are called on to design, those of boiler dimensions in details are the most important.

The boiler, with its relative parts, is the most important part of the locomotive. On its power to meet necessary requirements depends to a great extent the economy and efficiency of our lines of transportation. There are some grounds for the belief that, if the design and dimensions of locomotive boilers were given thought to as great a degree as that directed to improving the compound principle in locomotive engines, the result would be much more satisfactory in the directions of both economy and efficiency.

In all parts of boiler erection the inspector should play a ruling part and should be granted the greatest freedom in reaching conclusions as to the character of the work performed. There is scarcely a doubt that the strength and quality of boiler plate are often overtaxed and unduly strained while in the hands of a boiler-maker. The plates have to undergo the various

processes of heating and cooling, hammering hot and cold, bending, twisting, flanging and punching, to say nothing of the evil of the drift-pin or of hidden defects which are likely to occur in the plate.

There is certainly a possibility of bad and careless riveting, plates over heated in flanging, or cracked, if only slightly, in bending, and many other defects which may be traced to want of skill or reckless negligence on the part of the workmen.

It is clearly evident that the material for a boiler may be of the most superior quality sanctioned by use, and yet if not skilfully handled and most carefully attended to during the process of preparation to take its place in the completed boiler, it may be reduced to a point less in strength and endurance than material of the most inferior grade.

If we are to take the strength of the plate and the value of the joints, as they appear at their best in the finished boiler, as a means of ascertaining its resisting power and factor of safety, how uncertain it might be if we neglected to inspect and investigate in detail the methods followed in its erection.

The writer has seen, however, some cases of dangerous defects due to poor construction, which the strictest scrutiny of the completed boiler would fail to detect, brought to light by the test power combined with careful inspection. It is, however, a much better plan to compel carefulness in construction.

Opinions differ as to the best means of applying pressure in order to ascertain the strength of a boiler. Some advocate the hydraulic, others the steam test. In favor of testing by steam, it is urged that it is the only means by which the conditions of strain can possibly be the same as those under which the boiler is worked. No doubt this is in the main true, but as a matter of safety a steam test should only be applied after the strength of the boiler has been ascertained by the water test.

In making a full test of a boiler, new or old, before a pressure is applied, the various parts, particularly those suspected of weakness, should be measured and gauged and the results carefully noted. After the test pressure (which should not be more than 40 per cent. in excess of the working pressure) is maintained for some time, the measurements previously obtained should be checked, and any extension, changes of form, distortion, bulging, etc., carefully noted. Then, again, after the pressure is released any changes in measurements that may have been found should be known, whether permanent or not; and it seems to the writer that right here is a highly important point, one that should receive the most serious thought in that, if there be any permanent enlargement or distortion, even in the slightest degree, it should be thoroughly examined to decide whether it is due to the elastic limit of the material having been exceeded, or to improper construction. In all cases where permanent set is discovered the test should be repeated again and again if necessary, in order to ascertain if the set becomes increased.

In whichever manner a boiler is tested too great care cannot be exercised in obtaining the exact amount of pressure applied. Gauges in general use are too apt to get out of order to be implicitly trusted, when only a single gauge is used. It is, therefore, urged and recommended that in all cases of important boiler testing not less than two gauges be used, in order to establish to a certainty the exact pressure applied.

It may be remarked here that the test pressure should be maintained for some considerable time, say, half an hour or more. The continued pressure has often been known to lead to the detection of weakness, when, if such pressure had not been maintained, the defect would have escaped unobserved.

The question as to whether a boiler is strained more severely by steam than by hydraulic pressure will be found to resolve itself almost entirely into the question of construction. It is possible to design a boiler that would explode at low steam pressure and which would not be unduly strained by a hydraulic pressure three times as great. A boiler being steamed is often strained in a longitudinal direction, mostly in unequal expansion of the top and bottom shell, due to the greater expansion of the tubes, especially when the firing is forced, in getting up steam after the boiler has been cold. As this straining would not take place in testing the boiler with hydraulic pressure, and leaks due to unequal expansion would not be produced, it follows that the hydraulic test must fail to indicate weakness, which must be produced and made apparent by the steam test. From this it would appear that all boilers when new, or newly repaired, should be tested first by hydraulic pressure, and after by steam, the latter to determine what, if any, unequal expansion exists, to what extent, and what results have been produced.

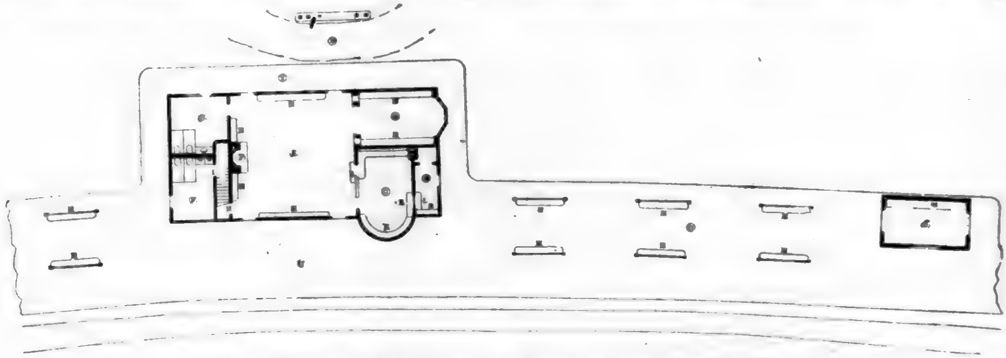
The wear and tear of a boiler in service is an important feature for the inspector to keep in mind. From the hour the boiler is set at work it is acted upon by destroying forces, and many of them are almost uncontrollable in their work of deterioration. Internal corrosion is the malady that most boilers suffer from. Corrosion presents itself in various forms. Sometimes it happens that it is mainly the transverse seams, rivet heads and plate-edges that are attacked; in other cases it is the longitudinal seams alone.

The stays are often more violently attacked and more rapidly wasted than the plates. A threaded stay will be attacked at the thread, while the unbroken or unturned surfaces will escape.

The body of a plate away from any disturbing influence is often attacked by furrowing and pitting, and in consequence of this apparent weakness has often been condemned and removed. The writer has seen plates removed from this cause when, although corrosion had taken place to some extent, there was left much more metal, and consequent strength, than was possessed by the next section of the plate through the rivet holes. This is an expensive mistake, and inspectors ought to guard against it.

As corrosion, as a whole, on the inside of a boiler is one of the most destructive elements we have to contend with, periodical inspection of its inroads must be made and met with the highest degree of care and intelligence. Of course the frequency of such inspection must depend on local conditions, essentially on the proportion of the destructive power contained in the water used and the relative amount of water evaporated.

Much is lost by improper care and unintelligent management of boilers in service. It seems unnecessary to remark that the management and care of boilers should be treated with as great a degree of intelligence as their design and construction. Excellent points to avoid are sudden and unequal expansion and contraction as a whole or in part. Blowing out a boiler while hot and washing it out with cold or comparatively cold water immediately thereafter is one of the most destructive and expensive practices of the service. Rapid and forced firing in a boiler which has been out of service and permitted to cool is also a boiler evil of the highest order. Permitting the entrance of cold air through the door

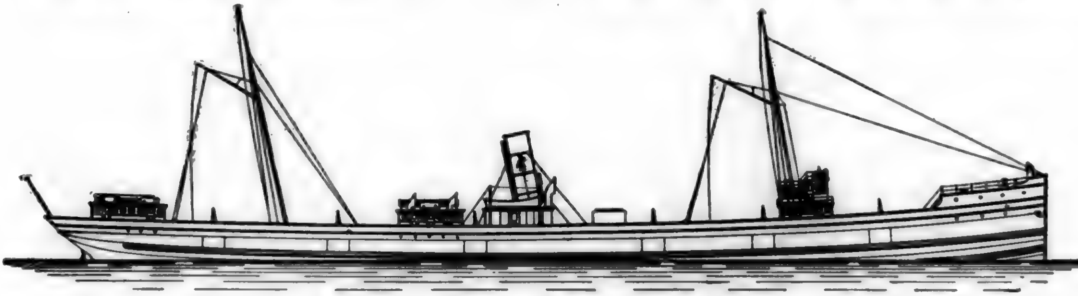


PLAN OF LIBERTY STATION, NEW YORK, ONTARIO & WESTERN RAILROAD.

or dampers immediately following the dumping of the fire is on a par with the worst evils, and its result is always apparent by the development of leaks.

To the correction of such disturbing elements as the above, together with numerous abuses in the care of boilers, it is desired to direct the attention of inspectors, but the extent of correction will depend largely on the intelligence and common sense of the persons charged with inspectors' duties. It is readily seen that on the proper fulfilment of boiler inspection depends much public comfort, public expenditure, and safety to public life and property. To perform the duties of boiler inspectors conscientiously and well the position can be no sinecure, and it can only be successful with the aid of experience in boiler design, construction, and requirements, together with a full understanding of the direction in which the forces are applied while in service, as well as under the stresses of test.

Do we hear mutterings among co-workers that this advice relating to the qualification of a boiler inspector is good enough, but is much easier stated than obtained? Begging to assure you that we are aware of this, gentlemen, let us inquire whose fault it is. Is it not to be laid to the indifference of the men long in charge of machinery departments, in not encouraging the required attainments in reaching proper boiler design and construction, and not appreciating to the proper extent those qualifications when presented?



THE "CENTURION," BUILDING BY F. W. WHEELER & COMPANY.

THE LIBERTY STATION OF THE NEW YORK, ONTARIO & WESTERN RAILROAD.

We illustrate herewith the station which is now being built at Liberty, N. Y., for the New York, Ontario & Western Railroad Company, with Mr. Bradford L. Gilbert as architect.

As shown by the perspective drawing, it is a wooden building with a long platform and an awning. At each end of the platform there is a small baggage-room, and at the south side of the building is a *porte-cochère*. On the first floor there is a general waiting-room, which is 28 ft. square. Off of this there opens the woman's alcove, which is 13 ft. × 19 ft., and has a bay window. The telegraph office, which occupies that portion of the building between the woman's alcove and the track, is 20 ft. × 12 ft. There is a special entry on the platform end of the building for trainmen, giving them direct access to the telegraph office, and is 5 ft. × 11 ft.

The woman's toilet is 13 ft. × 13 ft., and the men's 9 ft. 6 in. × 14 ft. 6 in. On the second floor is the operating-room and office. The former is 15 ft. 6 in. × 20 ft., and the latter 8 ft. × 16 ft. The plan and perspective give a very clear and distinct idea of the general appearance of the station, which is 29 ft. wide and 60 ft. 6 in. long, while the awning is 20 ft. wide at its widest part.

F. W. WHEELER & COMPANY'S ONE HUNDREDTH VESSEL.

"Centurion" is to be the name of the one hundredth vessel to be built at the yards of F. W. Wheeler & Company, West Bay City, Mich. The keel for this steel freight steamer was laid on Thursday, March 2, the fortieth birthday of Mr. Wheeler, and was made the occasion of a banquet at the Fraser House parlors, in Bay City.

One of the modern features of the *Centurion*, which is included also in Nos. 94 and 95, building at this yard for the Hawgood & Avery Transportation Company and D. C. Whitney, Detroit, is the placing of the engines and boilers amidships, thus lessening the strains to which the hull is subjected when boilers and machinery are placed aft. This is a departure from the usual practice of lake builders, and is adopted for the first time by F. W. Wheeler & Company. A glance at the accompanying photogravure illustration will give the best idea of what the most modern freight steamer on the lakes will look like when completed. The following are her principal dimensions: Length over all, 378 ft. 6 in.; length of keel, 360 ft.; breadth, extreme, 45 ft. 2½ in.; breadth, molded, 45 ft.; depth, molded, 26 ft.; depth of hold, 18 ft. 2½ in.; height between decks, 9 ft. 2 in.; height of forecastle, 7 ft. 6 in.

Especial care has been taken in her scantlings to place her in the highest class obtainable both in the American Shipmasters' Association and the English Lloyds, the rules of which she exceeds in many cases. All the material used in her construction is tested to stand a tensile strength of 60,000 lbs., with an elongation of 25 per cent. in 8 in., and is of the best open hearth steel.

Another feature is that the shell plating butts will be overlapped instead of butt strapped, and riveted throughout with three complete rows of rivets. In riveting, steel rivets will be used, which will give greater sheering strength. All stringers and longitudinal butts will be treble riveted throughout, and the spar deck stringer is double butt-strapped, especial care being taken to insure both in shell and longitudinal ties a clear shift of butts of from two to three frame spaces. Two 20-in. hold stringers aside run her entire length, and an extra one is fitted in the fore hold, which will extend through the collision bulkhead and will be connected to the panting stringer, which will prove a factor of safety in case of meeting heavy ice. Her forefoot will be cut away in ocean style to allow her to be quick on the helm.

The *Centurion* will be fitted with water ballast, having a cellular double bottom differing from the ordinary floor system employed in lake practice. The bottom will extend fore and aft, will be 54 in. deep, and will have a capacity of 1,600 tons, and there will also be a trimming tank aft. The sheer strake is extra heavy, and doubled for the entire length of the vessel. Web frames are spaced 16 ft. apart throughout the vessel, extending to the spar deck, and the deck beams are supported by three tiers of extra heavy I stanchions. She has been designed with special reference to the safe and quick handling of both package and bulk cargoes, every modern appliance in the shape of deck winches and steam hoisting gear being adopted to carry out this aim; between hatches in between decks are placed six large gangway ports on each side, thus insuring dispatch in loading and unloading cargo. The American Ship Windlass Company, Providence, R. I., furnish the No. 6 steam windlass and the E pattern steam capstan. These machines are too well known to necessitate a description. The steam steering engine is by Williamson Brothers, Philadelphia, and is arranged for both hand and steam. The engine is placed amidships, and is easy of access from the main engine-room.

The boat will be lighted throughout with electricity, having a 210 light dynamo, operating under 110 volts. One hundred and twenty-five 16-candle power incandescent lights will be distributed in the different cabins, and for lighting the decks six large lights are furnished. The cabins will be well ventilated and roomy, and elaborately finished in hard wood, the captain's and spare cabins being in the style of Louis XVI., making them equal to the best passenger boats on fresh water. The rig will be a fore-and-aft schooner with two pole masts well raked, and standing gaffs. The pilot house and texas will be well aft, which will add to the appearance of the boat, making her more ocean-like than the usual lake style of steamer.

The *Centurion's* motive power will consist of a modern triple-

expansion engine, built by F. W. Wheeler & Company in their own shops, with cylinders 23, 37½ and 63 in. × 44 in. stroke, driving a Trout wheel of 13 ft. 6 in. in diameter. The cylinders are placed in the sequence of high, intermediate and low pressure. The valves are actuated by the ordinary Stephenson link motion. The high-pressure and intermediate-pressure cylinders have each a piston valve, and the low pressure cylinder has a double-ported balance slide valve. The links are of the double barred type, and the motion is reversed by steam, the diameter of reversing cylinder being 12 in The bedplate is cast in one piece, and the framework consists of three straight cast-iron columns on the starboard side, and three Y-shaped columns on the port side, having very large bearing surfaces for the slides, and through bolts are used throughout. The cross-heads and connecting-rods are forged of the very best wrought iron. The piston-rods are 5¾ in. in diameter, of the very best machinery steel. The crank shaft is built up, and has a diameter of 12 in., the cranks being set at an angle of 120°. The thrust shaft has four large thrust collars, proportioned for a maximum thrust of 60 lbs. per square inch. The intermediate shafting is 12 in. in diameter and in 20-ft. lengths, supported by six line shaft bearings. The stern tube is fitted with an internal lignum vitæ bearing 5 ft. long. The center of the engine is placed 132 ft. from the after side of the stern post, and has a tunnel of ample size to allow free access to the whole length of shafting.

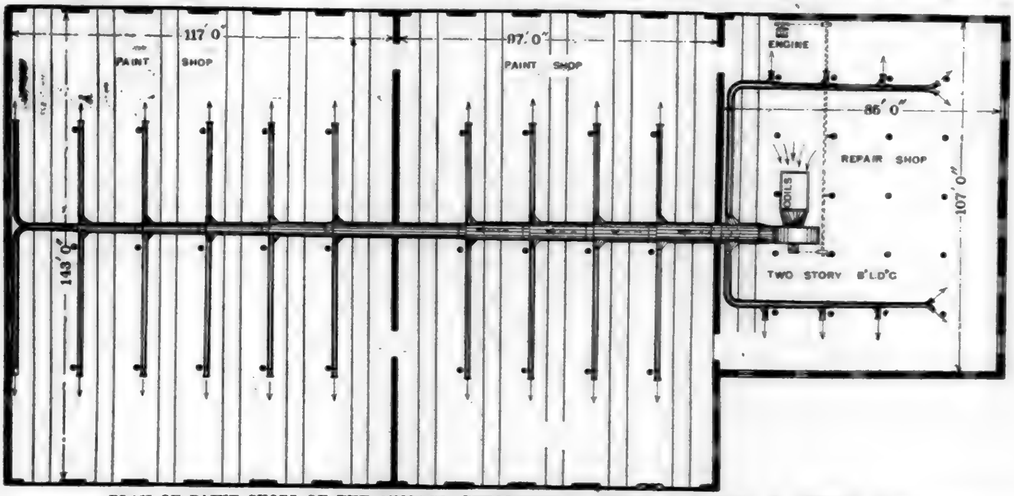
The condenser is independent, of Dean Brothers' type, the feed pump, duplex feed pump, bilge pump, cooler pump, deck pump and ballast pumps being supplied by the same company. The ballast pump has a capacity of 3,000 galls. per minute for emptying all the ballast tanks. Steam will be furnished by three cylindrical boilers of the return tubular type, 12 ft. 6 in. in diameter and 12 ft. 8 in. long, working at a pressure of 170 lbs. Each boiler has three 40-in. diameter furnaces, the total grate surface being 190 sq. ft., and the heating surface will be 6,500 sq. ft. The coal bunker capacity is 250 tons. A feed water heater of 24 in. in diameter is fitted on the line of feed piping containing fifty four 1¼-in. brass tubes 8 ft. long, and three double tube injectors are also fitted in addition to the feed pumps. The main steam pipe is provided with necessary slip joints, and is made of copper, carried below deck, as also are the receiver and exhaust pipes into condenser. The ship is to be heated with steam throughout.

When 23 years old, Mr. Wheeler established a small repair yard at West Bay City, and during the first three years built six small vessels, in addition to doing considerable repair work. But in 1880 he commenced building large wooden steamers, and in that year turned out the *Lycoming* and *Conemaugh*. In 1889 the steel plant was established, and work was commenced on the steel hull side-wheel passenger steamer *City of Chicago*, and she was completed in June, 1890.

PAINT SHOPS OF THE CHICAGO, BURLINGTON & QUINCY RAILROAD, AURORA, ILL.

WE illustrate the ground plan of the paint-shops of the Chicago, Burlington & Quincy Railroad, at Aurora, Ill., which have been equipped with the Huyett & Smith Manufacturing Company's heater and blower. The blower is set on the second floor of the repair shop building, and the pipes run along the roof-timbers of the two paint shops, which are each 22 ft. high. The paint shops themselves are only one story high, but are 22 ft. from floor to ceiling or roof-timbers, as we have already said. The repair shops are two stories high, one of 17 ft. and the other of 13 ft. respectively. Just before the main pipe passes through the first wall a branch pipe is taken out and run along the ceiling of the first floor of the repair shops, as shown in the engraving, which heats the second floor. Branch pipes from the main line which enters the main paint shops lead off and run along the ceiling to the first post, when they turn down and down to within about 7 ft. of the line, and discharge toward the outer wall, as shown. These branches are 12 in. in diameter, while the main pipes vary from 16 in. at the farther extremity to 54 in. at the delivery from the fan. The coil contains 12,000 lineal ft. of 1-in. steam pipe. The fan is a 96-in. steel plate blower, which at a minimum speed will produce a pressure of ½ oz. per square inch, which is sufficient to change the entire air in the building every 16 minutes, while if delivering at a pressure of 1 oz. the entire air will be changed every 8 minutes. The blower is driven from a counter-shaft on the ceiling of the first story, which is in turn driven by the vertical engine on the first floor next to the outer wall.

Live steam is used in the heater in cold weather, and exhaust steam in mild weather, or the two may be commingled as desired ; the steam enters the coils from the top header in the upper left-hand corner, and passes out through the header in the lower right-hand corner to the drip pipe.



PLAN OF PAINT SHOPS OF THE CHICAGO, BURLINGTON & QUINCY RAILROAD, AT AURORA, ILL.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

WE begin herewith the publication of a monthly list of accidents to locomotive engineers and firemen. The purpose of this publication is to make known the terrible sacrifice of life and limb among this class of people, with the hope that the collection and publication of information, as full as is obtainable, will indicate some of the causes of accidents of this kind and help to lessen the awful amount of suffering due directly and indirectly to them. We will be much obliged for any information from any source which will help us to make our list as complete and correct as possible, and which will indicate the causes or the cures for any kind of accidents which occur. The following list includes only a portion of the accidents which occurred during the month of February :

ACCIDENTS IN FEBRUARY.

Rome, N. Y., February 14.—A New York Central fireman, named Schlieper, fell from a locomotive near Rome, N. Y., to the ice, 12 ft. below a bridge, and was so badly hurt that recovery was thought to be hardly possible.

Erie, Pa., February 13.—An engine on the Nickel Plate Railroad left the track near Wallace Junction while the train was running at a high rate of speed, and turned at right

angles to the road, "bounced over," crushing William Lipwalder, the fireman, to death. Engineer O. W. Wilkins was also buried in the debris, but at the time the accident was reported he was said to be still alive.

Bristol, Tenn., February 13.—At Norton's Summit a freight train ran off the track and rolled down the mountain a distance of 100 ft. Engineer Allen was killed and Fireman Pettijohn was seriously injured.

At about the same time a freight train ran into a slide at Seven Mile Fords. The engine and six cars were precipitated down a hill, and Engineer John Smith had one leg broken and was otherwise injured. Fireman Marion was seriously hurt.

Portsmouth, O., February 16.—An engine on the Cincinnati, Portsmouth & Virginia Railroad was ditched at Coe's Station by striking a landslide. John Sprague went over with the engine, and was so badly scalded that he will die. The engineer jumped and saved himself.

Baltimore, O., February 16.—John Hahn, a fireman on the Baltimore & Ohio Railroad jumped off an engine at Light and Wells streets and slipped as he jumped, fell under the enginis which ran over him, crushing his right leg and left foot. He, leg was amputated, but his condition is critical.

Lockport, N. Y., February 16.—Herman Reck, a Buffalo, Rochester & Pittsburgh engineer, was killed in a wreck about two miles south of Springville.

Indianapolis, Ind., Feb. 16.—A "driving-rod" (?) on an engine on the Peoria & Eastern Railroad, near Moreland, broke and crashed through the cab, striking Andrew Losh, fireman, on the head, and fracturing his skull.

Springville, N. Y., February 17.—Two freight trains on the Buffalo, Rochester & Pittsburgh Railroad collided at Hayest. Herman Wreck, engineer of one of the trains, was fatally injured. The engineer and fireman of the north-bound train jumped, but Wreck stuck to his post.

Brazil, Ind., February 17.—A through freight train, north bound, on the Chicago & Indiana Coal Road, was stalled on Bush Creek grade, and was compelled to stop for assistance. Being aware that two heavy freight trains were closely following his train, the conductor sent a brakeman back to signal them.

The first train was stopped, but the engineer of the rear train failed to see the signal and dashed into the caboose of the train in front of his own, tearing it all to pieces and derailing several cars. E. Jackson, fireman, was crushed in the chest and became frantically insane, and had to be held to prevent him from jumping into the flames.

New Concord, O., February 17.—The boiler of engine No. 103 of the Baltimore & Ohio Railroad exploded at Norwood. The fireman was badly scalded.

Easton, Pa., February 18.—George Bimbler, a fireman on the Central Railroad of New Jersey, was injured at Annandale, N. J., and was reported in a critical condition.

Fort Worth, Tex., February 19.—By the explosion of a locomotive boiler on the Texas & Pacific Railroad, John Mills (colored), fireman, was horribly mangled and killed. Five other persons were injured. The fire-box, it is said, "blew off," and the cause assigned was weak stay-bolts and flues.

Brooklyn, N. Y., February 20.—An engine on the Prospect Park & Coney Island Railroad was derailed—it is said by a gale—and the fireman and engineer were injured.

Palmyra, N. Y., February 21.—A passenger train on the West Shore Railroad was derailed near this place and thrown down an embankment about 18 ft. high. Bert. Pearsall, the engineer, was badly hurt, and Fred Mentle (or Minth), the fireman, was seriously bruised.

Reading, Pa., February 21.—A shifting engine on the Pennsylvania Schuylkill Valley Railroad collided with a freight train near Spring City. Fireman McCord was seriously injured, and two men on the train were killed and two others injured.

Trenton, N. J., February 22.—In a collision at the Calhoun Street crossing, Engineer Weir was caught by the falling cab of his engine and pinned fast, so that he had to be pried out. He was only slightly hurt.

Willoughby, O., February 23.—A Lake Shore special train ran into a "light" engine at Wicklife at four A.M., killing Engineer James Gill of the extra. He was pinioned in the cab, with the lever through his body, and was otherwise horribly mangled. His fireman has not yet been found.

Cadillac, Mich., February 25.—Freight engine No. 40 blew up four miles south of this city on the Toledo & Ann Arbor Road this morning. Fireman Pat O'Neal was killed, his head being badly crushed and an arm torn off.

Naugatuck, Conn., February 24.—Edward Cosier, fireman, and Mr. Abel, engineer, were slightly injured in a wreck.

Augusta, Me., February 25.—The "driving-rod" of an engine on the Maine Central Railroad broke and went through the cab, throwing the engineer, Fred Little, out and fracturing his arm.

Westchester, Pa., February 25.—An engine ran into a number of cars near Birdsboro, on the Wilmington & Northern Railroad. The cab of the engine was partly demolished. Mr. Herflicker, the engineer, was thrown out of the cab by the force of the shock, and down through the trestlework of a bridge which spans a small stream at that point. He was injured internally and had several ribs broken.

New Haven, Conn., February 27.—In a collision in the cut between Court Street and Grand Avenue, Fireman Charles Bedell was crushed by the falling cab. His left hip was fractured, his left leg was broken, and he received internal injuries which were supposed to be fatal. He and his engineer stood bravely to their posts. Railroad officials said that the trouble was owing to the unexpected standstill of the local freight and the slipp ry rails, which would not allow the brakes to be effectual in a short distance.

St. Johnsbury, Vt., February 27.—In a collision of two freight trains on the Passumpsic Division of the Boston & Maine Railroad, near St. Johnsbury Centre, Fred Clark, engineer of the up train; Charles West, an engineer, who was riding on the same engine, and Fred Green, fireman on the down train, were killed. William Dowling, a brakeman, was hurt about the head, but not seriously. Engineer Napoleon Bedard, of the down train, saved his life by jumping. None of the other train hands were hurt. Fred Clark was living when first found, but died before he could be extricated from the ruins. The accident, it is said, was caused by the conductor forgetting his orders.

Washington, D. C., February 27.—A north-bound passenger train on the Pennsylvania Railroad collided with a side-tracked freight on the causeway of the long bridge crossing the Potomac River.

The engines of both trains were wrecked. Fireman Simpson, of the freight, was killed, and Engineer Mullowney and Fireman Kormik, of the passenger train, badly injured.

The telegraph operator at the bridge was arrested, charged with having caused Simpson's death by a failure to close the switch.

Meyersdale, Pa., February —.—A west-bound freight on the New York, Chicago & St. Louis Railroad left the track near Girard. The engine was totally wrecked, and Fireman William Lipwalder, of Mossiertown, was crushed to death under the tender. Engineer G. W. Wilkins, of Conneaut, O., was reported dead from injuries received, but was still alive at the time this report was made, though badly hurt. Head Brakeman John Walters, of Conneaut, had an arm broken and was badly hurt about the head.

Brooklyn, N. Y., February 27.—Engineer Lafayette B. Marshall, of the Long Island Railroad, had his foot amputated by the wheels of his engine yesterday. Marshall was running a wildcat locomotive from Long Island City to Whitestone Landing. At the Bridge Street Station, in Flushing, to side track his engine so as to allow the 2.11 train from Whitestone to pass, Marshall ran ahead and turned the switch, the engine following slowly. As the engine cleared the switch he attempted to jump on one of the side steps, but missed his footing and slipped beneath the wheels. His right foot was cut off at the ankle.

Terre Haute, Ind., February —.—While a fireman named Bean was making his first trip as fireman on Vandalia engine No. 267, he got down near Marshall, Ill., to stoke the ashes from the grate-bars, lost his balance, and fell frome the train, which was moving at the rate of thirty miles an hour. He was badly hurt internally about the head.

OREGON'S CANTILEVER BRIDGE.

Alfred B. Ottewell read a paper before the American Society of Civil Engineers upon combination bridges on the Pacific Coast. He confined his observations, however, to two examples, which he said had already stood tests as severe as any which will be brought to bear upon them. The first bridge referred to is the cantilever bridge across the North Umpqua River, near Roseburg. Of this Mr. Ottewell says:

"It is, as far as the writer is aware, the only combination cantilever of large span in existence. The shore arms are each 147 ft., the river arms 105 ft., and the suspended span 80 ft., making the distance between river piers 290 ft., and the distance between end or anchor piers 584 ft. The bridge, as constructed, illustrates the principle of the cantilever very simply. The river span is connected and supported by the river arms at four points only. The weight of the river span is balanced about the river piers by the anchor piers or weights at the outer end of the shore spans. As will be seen, there is

no connecting member between the hip panel points of the suspended span and river arms, the wind pressure on the upper chord of the suspended span being transmitted down the end brace to the bottom chord of the cantilever arms to the earth. The lower part of each pier is built of concrete, set on the solid rock of the river-bed. The upper part of each pier consists of two iron cylinders, filled with concrete, and braced by wrought-iron horizontal struts and diagonal ties. The bracing is protected from drift by timber sheathing on each side of the bracing. The up-stream cylinder was anchored down to the concrete base by two 1¾-in. galvanized iron rods, to increase the stability against drift. The smallness of the anchor piers is due to the unusual length of the shore arm as compared with the river span. As usual in the superstructure of combination bridges, the floor beams, joists, floor and railing are of wood. The compression members are of wood, with the exception of the struts and bottom chord panels next the river piers, which are of steel. The tension members are of iron, and the pins of steel; the chord-blocks, post-shoes, etc., being of cast iron. The shore arms were made of unusual length, so as to offer as little obstruction as possible to drift, of which there is considerable in the rainy season. The method of erecting the suspended span, without false work by working out from the river piers, was, to some extent, different from the usual method adopted for iron construction, since the compression members in combination work will not in themselves take tension, nor the tension members take compression; nor will any member take transverse loads or shear. For these reasons it was found necessary in the course of erection to introduce several temporary ties and struts.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

II.—METHOD OF DETERMINING FREE CAUSTIC AND CARBONATED ALKALI IN SOAPS.

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page 18, Volume LXVII.*)

OPERATION.

PUT into an 8-oz. flask 100 c.c. of an alcoholic solution of stearic acid whose strength in terms of standard alkali is known, and add 5 grams of the soap cut in fine shavings. Allow to dissolve at a temperature near the boiling point of the solution. As soon as solution is complete titrate the excess of stearic acid with standard alkali, using phenolphthaline as indicator. Now filter the solution through paper or through asbestos in Gooch crucible, using the pump, and wash with absolute alcohol until the last drop of the filtrate, evaporated to dryness on a clean piece of platinum, leaves no residue. Dissolve whatever is left on the filter in warm water, and wash with water until same test as above shows no residue. The solution and washings should amount to about 100 c.c. Add now enough standard sulphuric acid to render the solution distinctly acid to litmus paper after boiling, and boil not less than 15 minutes. Then titrate the excess of acid with standard alkali, using phenolphthaline as indicator. These two titrations show the total amount of free caustic and carbonated alkali in the soap.

Dissolve another portion of 5 grams of the soap, which has been previously cut in very thin shavings, and after weight has been dried at from 120° to 200° F., in the same kind of a flask, in 100 c.c. of absolute alcohol, using heat as before. As soon as solution is complete filter as before, and wash with hot absolute alcohol until the last drop of the filtrate, evaporated as before, shows no residue. Dissolve whatever is left on the filter in warm water and wash as before; then render acid with standard sulphuric acid, boil and titrate as before. This last titration gives the amount of carbonated alkali in the sample, and the difference between this and the sum of the first two titrations gives the amount of free caustic alkali in the sample.

APPARATUS AND REAGENTS.

The apparatus required by this method is simply flasks, burettes and pipettes, none of which need especial description. We use ring-necked, flat-bottomed flasks, holding about 8 oz., burettes of 50 c.c. capacity, graduated to tenths, which have been calibrated and compared with each other, and 100 c.c. pipettes, which have been compared with the burettes.

The stearic acid solution is made by dissolving 15 grams of stearic acid obtained in the market in 2 liters of commercial 95 per cent. alcohol.

The phenolphthaline solution is made by dissolving 5 grams of the commercial material in 100 c.c. of 95 per cent. alcohol, and adding caustic potash until the solution shows slight pinkish tint.

The standard alkali and acid solutions are made as follows: Take about 50 grams of the best dry C. P. carbonate of soda, free from silicate, to be obtained in the market. Dissolve in distilled water and filter into a platinum dish. This is to remove any sand or dirt that may be accidentally contained in the soda. Add a little carbon dioxide or a few drops of carbonic acid water, in order to be sure that there is a slight excess of carbonic acid present. Evaporate the solution to dryness at a temperature a little above the boiling point of water, using great care to keep out the dust or dirt. When thoroughly dry transfer to a dry glass-stoppered bottle for further use. Now carefully weigh a clean ½ oz. platinum crucible and add to it about a gram of the dried carbonate of soda, ignite over a Bunsen burner until the soda is just melted, and weigh. This weight gives the amount of carbonate of soda used, and is the basis of the standardizing. Have previously prepared two solutions made as follows: 1. A solution of distilled water to which has been added about 26.5 grams of concentrated C. P. sulphuric acid per liter. The solution should be thoroughly mixed, and allowed to cool before using. 2. A solution of caustic potash in distilled water, made by adding to it about 50 grams of commercial stick potash per liter, allowing to dissolve, and then adding to it ½ liter of milk of lime, made by slacking 70 grams of commercial caustic lime and diluting with water to one liter. After the lime is added boil for 10 or 15 minutes; then allow to settle and draw off with a pipette about 50 c.c. of the clear solution, transfer to a beaker, and add a few drops of phenolphthaline. Then run in from a burette some of the sulphuric acid solution above described, until the last drop just discharges the color, and boil. If five or 10 minutes' boiling does not bring back any of the pink color, the caustic potash solution may be regarded as free from carbonates, and is ready to be proceeded with. If boiling does restore any of the pink color, the boiling with the lime must be continued, or fresh milk of lime added and boiling continued, until the solution is free from carbonates by above test. After carbonates are proven absent, filter the solution into the vessel in which it is to be kept for use, taking care to avoid exposure to the air as much as possible.

The two solutions thus prepared should be rendered homogeneous by stirring or shaking, and should then be allowed to stand until they are both of the temperature of about 70° F. This being accomplished, the strength of each in terms of the other must be known. For this purpose run from a burette 40 c.c. of the acid solution into a beaker, add a few drops of phenolphthaline, and then titrate with the caustic potash solution. Two or three tests should give the same figure within one or two drops. Preserve the figures thus obtained.

Now put the crucible containing the fused carbonate of soda before described into a beaker, add about 50 c.c. of distilled water, and allow to dissolve. Then add about 50 c.c. of the sulphuric acid solution above described and boil 15 minutes to remove carbon dioxide, taking care that there is no loss due to effervescence. After the boiling is finished titrate the excess of acid with the caustic potash solution, using phenolphthaline for the indicator. The relation of the acid and alkali being known as before described, it is easy to find the amount of the sulphuric acid solution corresponding to the carbonate of soda taken; but one point still remains uncertain—viz., whether the boiling has removed all the carbon dioxide. To decide this point, add to the solution which has just been titrated with the potash solution, and which the last drop of potash rendered pink, one drop of the acid solution, or enough to just completely discharge the color and boil again. If the color does not reappear on boiling, the figures already obtained may be regarded as satisfactory. If the color does reappear, run in one or two c.c. of the acid and boil again. The amount

of acid thus run in must be added to the 40 c.c. used at first. After boiling, say, five minutes more, titrate with the potash solution, noting how much of it is required to bring back the pink color, and adding this amount to the amount of potash solution previously used. Now test as before for the absence of carbon dioxide, and if it is proven not present, find the total number of c.c. of the sulphuric acid solution, which is equivalent to the carbonate of soda used. From this, as described below, the amount of sulphuric acid (H_2SO_4) in one c.c. of the acid solution may be obtained. But convenience in the subsequent use of the acid solution makes it desirable that each c.c. of it should contain a definite proportion of the molecular weight of sulphuric acid, say one-fourth or 0.0245 grams H_2SO_4. If sufficiently concentrated C. P sulphuric acid has been used in making the solution to start with, the figure obtained as above will be larger than this, and, as shown in the calculations below, a certain amount of water must be added, which should be done, the solution being agitated by stirring or shaking, and then allowed to stand until the following day, when a new determination of its strength should be made by means of carbonate of soda, as above described. The figure thus obtained will show whether further addition of water is necessary. When all the water needed has been added, not less than two determinations of the strength of the acid should be made by means of carbonate of soda, as described above, which duplicates should show the value of 1 c.c. to be not less than 0.0244 gram, nor more than 0.0246 gram of sulphuric acid (H_2SO_4).

The standard acid having been obtained, it remains to make the caustic potash solution so that 1 c.c. equals 1 c.c. of the acid solution. For this purpose run, say, 40 c.c. of the standard acid into a beaker, and titrate with the caustic potash, using phenolphthaline as indicator. If fairly good caustic potash has been used in making the solution, this operation will show that water must be added. If the operation shows that the solution is too weak, it is better to throw it away and start again, using more of the potash per liter. The figure obtained enables, as is shown below, the amount of water that must be added to be calculated. This amount of water should be added, the solution agitated by stirring or shaking, and allowed to stand until the following day, when a new test should be made. The figure thus obtained will show whether further addition of water is necessary. After all the water has been added, not less than two tests should be made, and each of these should show that the two solutions are alike to within one-tenth of a c.c.

CALCULATIONS.

An example of all the calculations is given herewith.

I. *Standardizing the Sulphuric Acid.*—Suppose that 40 c.c. of the sulphuric acid as mixed requires 36.4 c.c. of the caustic potash as mixed to exactly neutralize it, this figure having been obtained by two or three closely agreeing tests. This means that 1 c.c. of the sulphuric acid solution is equal to ($36.4 \div 40$) 0.91 c.c. of the potash solution, and that 1 c.c. of the potash solution is equal to ($40 \div 36.4$) 1.0989 c.c. of the acid solution. Next suppose the fused carbonate of soda in the crucible weighs 0.9864 grams, and that 45 c.c. of the sulphuric acid as mixed are run into the solution of this carbonate of soda; also that after boiling it requires 9.2 c.c. of the potash solution to neutralize the excess of acid; also that it is found that the carbon dioxide is not quite all removed by the first boiling, and that 1 c.c. more of the acid is put in for a second boiling, and that after this second boiling it requires 0.4 c.c. of the potash solution to neutralize the excess of acid, and that test shows that the second boiling removed all the carbon dioxide. It is evident that 46 ($45 + 1$) c.c. of the acid have been used all together, and that 9.6 ($9.2 + .4$) c.c. of the potash solution have been used to neutralize the excess of acid. But 1 c.c. of the potash solution is equal to 1.0989 c.c. of the acid, or 9.6 c.c. of the potash solution are equal to (1.0989×9.6) 10.55 c.c. of the acid solution. Hence the amount of the acid solution used up by the 0.9864 gram of carbonate of soda is 35.45 ($46 - 10.55$) c.c. or 1 c.c. of the acid solution is equivalent to ($0.9864 \div 35.45$) 0.027825 gram carbonate of soda; but the ratio of the molecular weights of carbonate of soda (Na_2CO_3) to sulphuric acid (H_2SO_4) is as 106 to 98. Hence each c.c. of the sulphuric acid solution contains ($106 : 98 :: 0.027825 : x$) 0.025725 gram sulphuric acid. But, as previously stated, it is more convenient to have the acid and alkali solutions some even ratio of the molecular weight, and therefore a solution is wanted which contains ($98 \div 4$) 0.0245 gram of sulphuric acid per cubic centimeter. To obtain this, water must be added to the solution in question. The amount of this is found by the following ratio, $a : b :: x : c$, in which a represents the strength of the acid as determined, in this case 0.025725 gram, b the strength of acid desired, in this case 0.0245 gram, c the total volume of the solution we are working with, say, 15000 c c., and x the volume of the solution after the water is added, which in the case supposed is ($0.025725 \times 15000 \div 0.0245$) 15750, or ($15750 - 15000$) 750 c.c. of water must be added.

II. *Standardizing the Caustic Potash Solution.*—Suppose that it is found that 40 c.c. of the standard acid require 31.2 c.c. of caustic potash solution as made to exactly neutralize it. This means that water must be added, and the amount may be found by the proportion, $a : b :: x : c$, in which a represents the number of c.c. of standard acid used, in this case 40; b the number of c.c. of potash solution used, in this case 31.2; c the total volume of the solution we are working with, say, 15000 c.c., and x the volume of the solution after the water is added, which in the case supposed is ($40 \times 15000 \div 31.2$) 19230, or ($19230 - 15000$) 4230 c.c. of water must be added. The reaction between sulphuric acid and caustic potash being represented by the equation $H_2SO_4 + (KOH)_2 = K_2SO_4 + (H_2O)_2$, or by weight $98 + 112.2 = 174.2 + 36$, it must be remembered that, since 1 c.c. of each solution is the equivalent of the other, the actual amount of caustic potash (KOH) in each c.c. of the solution is ($112.2 \div 4$) 0.02805 gram—that is, if a solution containing any substance which reacts with sulphuric acid is so made that 1 c.c. equals 1 c.c. of the acid, the value of 1 c.c. of the solution in question may be found by writing the equation which expresses the reactions, together with the molecular weights, and dividing the molecular weight as given in the equation of the substance sought by the same figure that is required to give the known strength of the standard sulphuric acid. Further, the quotients thus obtained may be used interchangeably, according to the work in hand. Thus 1 c.c. of the standard sulphuric acid or 1 c.c. of the standard caustic potash is the equivalent of 1 c.c. of a solution containing 0.02355 gram of potash (K_2O), or of 0.020 gram of caustic soda (NaOH), or of 0.0155 gram of soda (Na_2O), or of 0.0265 gram of carbonate of soda.

III. *Caustic and Carbonated Alkali in Soap.*—Suppose 100 c.c. of the stearic acid solution requires 6 c c. of the standard potash solution to exactly neutralize it, and that after the soap has been dissolved in this it requires 4.3 c.c. of standard potash solution to exactly neutralize the excess of stearic acid. Also suppose that to the water solution of the material left on the filter from the first 5 grams, 5 c.c. of standard acid are added, and that after boiling 3.2 c.c. of standard potash are required to exactly neutralize the excess. It is clear that the total caustic and carbonated alkali in the 5 grams of soap under test are the equivalent of ($6 - 4.3 = 2.7$) + ($5 - 3.2 = 1.8$) 4.5 c.c. of standard potash solution. Next suppose that to the water solution of the material left on the filter from the second 5 grams 5 c.c of standard acid are added, and that after boiling it requires 2.9 c.c. of standard potash to exactly neutralize the excess. It is obvious that the carbonated alkali in the sample under test is equivalent to ($5 - 2.9$) 2.1 c.c. of the standard potash solution, also that the caustic alkali in the sample is equivalent to ($4.5 - 2.1$) 2.4 c.c. of the standard potash solution. But each c.c. of the standard potash solution is equivalent to 0.0265 gram of carbonate of soda, and to 0.020 gram of caustic soda. Hence the 5 grams of soap contains 0.05565 gram of carbonate of soda and 0.048 gram of caustic soda or ($5 : 100 :: 0.05565 : x$) 1.113 per cent. of carbonate and ($5 : 100 :: 0.048 : x$) 0.96 per cent. of caustic soda.

Notes and precautions on this method will follow.

PROCEEDINGS OF SOCIETIES.

Boston Society of Civil Engineers.—A regular meeting was held on February 15. Mr. W. E. McClintock gave an account of the work of the Massachusetts Highway Commission, illustrated by lantern views showing the condition of the roads throughout the State. Mr. E. W. Howe showed by lantern views the kind of roads built by the Boston Park Department, and Mr. E. F. Foss gave some of the streets in Chicago and Buffalo. A general discussion on road construction followed.

The New York Railroad Club held its regular March meeting on the evening of the 16th. Mr. Dixon, of the Rogers Locomotive Works, read a paper on the Locomotive Boiler, which was followed by a discussion turning chiefly on the methods of staying the fire-box, and especially the crown-sheet. In the course of the discussion it was stated that the chief trouble with the Belpaire form of boiler lay in the leakage which was apt to occur between the flat, top sheet over the fire-box and the shell, owing to the unequal expansions which occur.

The Engineers' Club of St. Louis held its 378th meeting on February 15. The paper of the evening was by Mr. O. W. Ferguson, on Methods and Results in Precise Leveling. Mr. Ferguson described the instrument used, the methods employed, and the causes of error. He cited results from different surveys, exhibited profiles, forms of note-books employed, and speed of working. He gave the cost of precise leveling at $18 to $21 per mile for field expenses. Cited a polygon of 4,000 miles in length, extending from Chicago to New York, Biloxi, New Orleans, back to Chicago, that closed with an error of 1 ft. Stated that bench marks had been established every 1¼ miles along the Missouri River from St. Louis to Sioux City by the Missouri River Commission.

Engineers' Club of Philadelphia.—At the regular meeting on March 4 Professor Joseph T. Rothrock delivered an address on Wood Structure in its Relation to Mechanical Purposes, explaining the effect of cellular and woody fibre upon the strength and durability of wood, and pointing out the predominance of one or the other kinds of growth in different trees, and their consequent adaptability to different purposes.

He explained that while the so-called annual rings might be used in counting the life of a tree, in most cases this was not an invariable rule, and one might be misled in following it in some cases.

He closed by showing the distribution of the timber area in the State of Pennsylvania, and called attention to the necessity for better supervision for its protection.

Engineers' Club of Cincinnati.—At the February meeting Mr. Oswald Dietz read a paper on the Peculiarities of Numbers, which was an explanation of the law or rule governing the fact that the square of any number cannot have as its last figure 2, 3, 7, or 8, and that the bi-square of every number which is not a multiple of 5 can have as its last figure only 1 or 6.

This was followed by one on a proposed plan for disposal of overhead wires in cities by Colonel Latham Anderson. The plan proposed was that of placing the wires directly over the sidewalks at a height of 18 ft. on suitable supports extending from poles on the curb line, about 80 ft. apart, to the buildings, and preventing the falling of the wires to the sidewalk in case of breakage by a mesh of wires with ground connection through the poles. Another plan would be the placing of the wires directly under the sidewalks in areaways between the curb and the house line. Sewer, water, and gas-pipes could also be so placed.

Engineers' Club of St. Louis.—The Club met on March 15, and Mr. Robert Moore read a paper on Some Notes on European Travel. By means of a chart the mileage, cost, receipts, expenses, etc., of the railroads of the world was clearly shown. The cost per mile was highest in Great Britain—$212,220—and lowest in Sweden—$29,100. The interest on capital was: 5.2 per cent. in India; 5.1 per cent in Germany; 4.1 per cent. in Great Britain; 3.1 per cent. in the United States, and 1.7 per cent. in Canada. The track and chair fastenings were illustrated by a number of photographs. This method gave a steadier track than the usual American method of using spikes only. A number of fine photographs showed the English engines and cars. The high cost of the English roads was shown to be largely due to the expensive bridges, terminals, etc. A marked feature of the English roads was the rapid handling and delivery of freight—freight received at London during the afternoon being delivered at any point the next morning. In Switzerland and Germany the metal ties are being largely introduced.

PERSONALS.

Mr. Alonzo Dolbeer has been appointed Master Mechanic of the Lehigh Valley Railroad, at Buffalo.

Mr. R. K. Mulcahy has been appointed Superintendent of the Oregon Pacific, with headquarters at Corrallis, Ore.

Mr. C. M. Lawler, Assistant General Manager of the Philadelphia & Reading, has been made General Superintendent of the main line.

Mr. William Renshaw has been promoted to be Superintendent of Machinery of the Illinois Central, succeeding Mr. Henry Schlacks. Mr. Renshaw has risen on the Illinois Central from a machinist. He was successively Foreman, Master Mechanic, and Assistant Superintendent of Machinery.

Mr. E. G. Russell has been appointed Superintendent of the Rome, Watertown & Ogdensburg, with headquarters at Watertown, N. Y. Mr. Russell was for several years Superintendent of the Illinois Central, and attracted considerable attention by the fight he carried on with the striking switchmen of that road at Chicago. He is a man of strong personality, and does not tolerate any interference with his authority.

Mr. Theodore N. Ely, formerly General Superintendent of Motive Power of the Pennsylvania Railroad, with headquarters at Altoona, has been appointed Director of Motive Power of the Pennsylvania lines, with his office at Philadelphia. F. D. Cassanave, heretofore Superintendent of Motive Power of the northwest system of the Pennsylvania Company, with office at Fort Wayne, has been appointed Mr. Ely's successor. G. L. Potter is promoted to the position vacated by Mr. Cassanave. W. W. Atterbury succeeds Mr. Potter as Master Mechanic of the Fort Wayne lines.

OBITUARIES.

Mr. Edward G. Gilbert, President of the Gilbert Car Manufacturing Company, died suddenly March 7 at his home in Troy, N. Y., aged 46 years.

Mr. C. H. Kendrick, who was General Ticket Agent of the New York Central from 1852–87, died at Elkhart, Ind., on the night of March 3, at the age of 70. Mr. Kendrick was born in Nashua, N. H., and his first railroad service was on the Nashua & Lowell. Before the consolidation of the New York Central and the Hudson River he was on the latter. From 1869–77 he was General Passenger Agent in addition to his other duties. After 1877 his title was Auditor of Ticket Accounts.

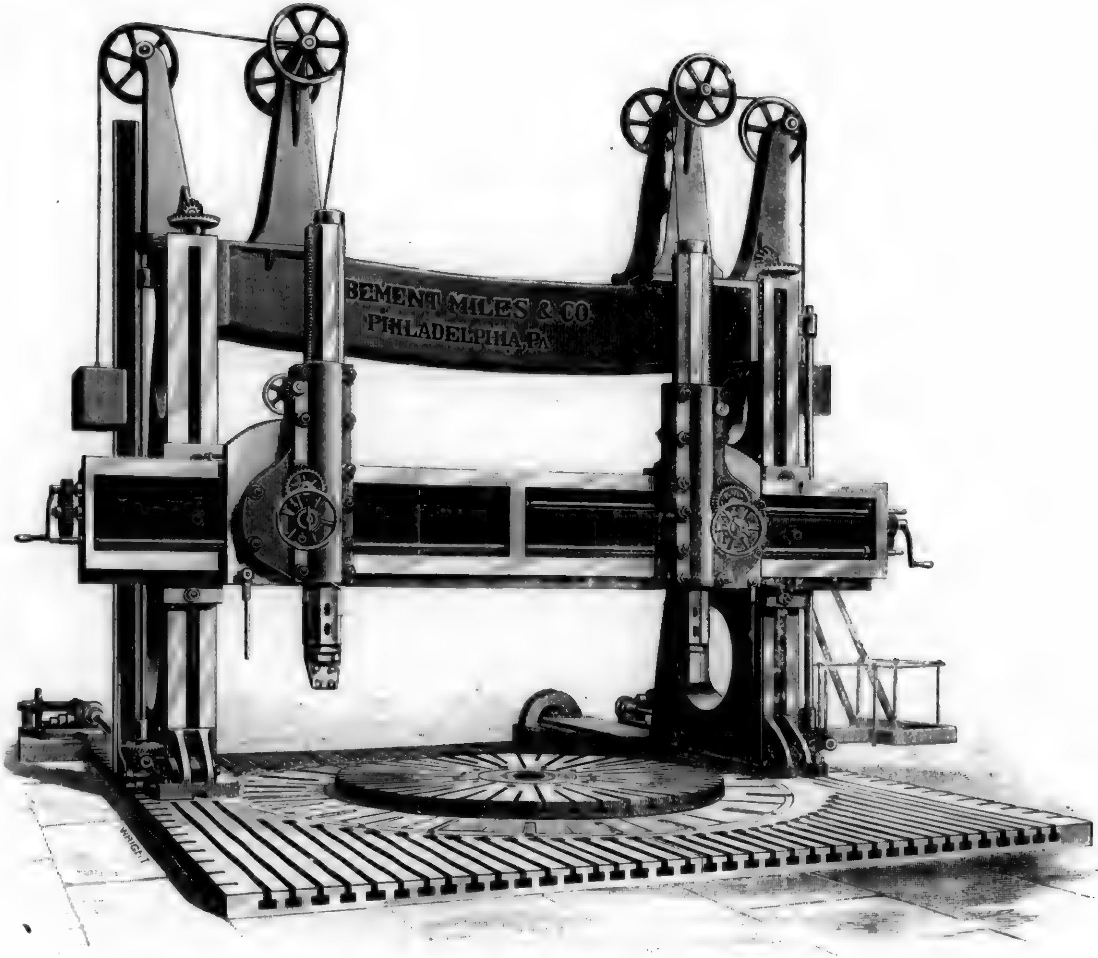
Colonel Richard Vose, the well-known manufacturer of car springs, died at Nyack, N. Y., February 25. He was born at Whitesboro, N. Y., in 1830, and when 24 years old was appointed Superintendent of the Manufacturing Department of the Metallic Car Spring Company, of New York. In 1868 he established the firm of Vose, Dinsmore & Company, and in 1876 its business was transferred to the National Car Spring Company, of whom he was elected President. He invented improvements in car springs and amassed a large fortune.

SOME CURRENT NOTES.

A Krupp Extension.—The Krupp firm keeps extending at a considerable rate. Their negotiations with Li Hang Tshang have now ended in an agreement, according to which the firm shall erect a large foundry and rolling mill at Kaiphing. These works will supply the railway material for the line from Tientsin to Shanghai Kuan and the contemplated extension to Nirin.

Forests Required to Supply Ties.—An estimate has been made that 1,000,000 acres of forest are required for the annual supply of wooden sleepers for European railways. These forests are properly managed so as to yield a steady return, while nothing of the kind can be said of American forests. This explains why German foresters are interested in watching the progress of forest destruction in America, where it is now merely a question of 10 or 15 years before a timber famine must occur, which will greatly enhance the value of European forests.—*Nature.*

Coal and the Channel Tunnel.—The engineer of the Channel Tunnel Company, Limited, makes the following statement in his recent report on the Trial Boring for Coal: "The coal boring has now reached a depth of 2,228 ft., including 1,071 ft. of coal measures in which nine workable seams have been found, containing altogether 20 ft. in thickness of good bituminous coal. This coal is suitable for gas making and household purposes. The deepest seam, 4 ft. in thickness, was met with at 2,222 ft. from the surface." So it looks as though this company may get something out of its coal mines, even if its tunnel comes to nothing.



LARGE BORING MILL FOR ROBERT POOLE & SON CO.

Fire Protection at Cleveland.—A novel system of fire protection is in use in Cleveland, O., which has proved quite successful. Four 6-in. mains are laid from Cuyahoga River to the business streets of the city, the distance being from 700 ft. to 1,000 ft. The mains are provided at intervals with ordinary fire hydrants, but are normally quite empty, as they are laid with a slope toward the river, into which they empty themselves. In a case of fire, the city fireboat is run to the river end of the mains, with which one of its nozzles is connected. The pumping engines in the boat are capable of putting on a pressure of 200 lbs. to 250 lbs. per square inch, so that a good pressure is available at the hydrants.

Electric Power for Seattle.—About fifteen miles from Seattle, Wash., the Snoqualmie Falls are formed by the descent of the Snoqualmie River over a precipice 268 ft. high into a gorge which broadens out quite rapidly into a fertile valley.

It is proposed by some wealthy capitalists to run an electric cable from the falls to Seattle. A series of turbine wheels will be placed at the foot of the falls, to which the water will be conducted by flumes, and they will transmit the power by means of shafting to an immense electric plant, where it will be transformed into a current and started over the cable to Seattle for distribution among the saw mills, street railroads, and all the different industries of the city. The cable will be laid under ground as nearly in a straight line as possible, only diverging to avoid two marshes and any inaccessible mountains which may be encountered, and passing under Lakes Sammamish and Washington, direct to the eastern limits of the city.

The initial plant will generate 5,000 H.P., and, the projectors say, will be in operation within six months. The capacity of the falls, of course, varies according to the volume of water in the river, but at the lowest in midsummer it runs into the hundreds of thousands of horse-power.

Manufactures.

ROBERT POOLE & SON COMPANY'S LARGE BORING MILL.

In the February number of the American Engineer we published an illustration and description of the shops of the Robert Poole & Son Company, in Baltimore, Md. Reference was then made to a large boring mill, which was indistinctly shown on the right-hand side in the view of the erecting shop. We give with this number an engraving of this mill, of which only the upper portion is shown. The driving gear, which is below the floor, is not shown. This part of the machine was made in the works of the Robert Poole & Son Company. The upper part, which is shown in our illustration, was made by Messrs. Bement, Miles & Company, of Philadelphia, to whom we are indebted for the following description:

LARGE UPRIGHT BORING MACHINE.

When the uprights are in their forward position, as shown in the cut, the total swing of the machine is 16 ft. 2 in. This can be increased to 24½ ft. or any intermediate distance by drawing the uprights backward upon the bed plate, for which purpose a power attachment is provided. The diameter of the table above the floor plate is 10 ft., but below the plate it is extended to 14½ ft., and carries a large spur gear of the same diameter, through which it receives its rotating motion. The table spindle is fitted with adjustable bearings for taking up wear. At the lower end of the spindle an arrangement is provided, if required, for raising it entirely off its upper horizontal bearing. The bed plate is 20 ft. wide and 34½ ft. long from front to back. Its upper surface is slotted, to receive any additional stands or tool posts that may be required. The cross-slide has a vertical depth of 37 in., and its length is sufficient for turning conveniently the largest diameters that the machine will receive. It is raised and lowered by a convenient power attachment to a height of 10 ft. above the table. The saddles are traversed independently upon the cross-slide, by hand or power, from either end of the slide, and also by special gearing arranged upon each saddle. The steel cutter-bars are counterweighted independently, and so arranged that the weight of the cutter-bars, as well as that of the counterweights themselves, does not come upon the cross-slide, but is supported upon the main framing. The cutter-bars are held and guided in long bearings at the inner edge of each saddle, so that they may be brought very close together when required. They can be swivelled to any angle by worm gear and screw, for boring or turning tapered. Their traverse motion at any angle is 6 ft., or more if required. They can be moved by hand or power—that is, either by the apparatus upon the saddle itself or by the crank handles and gears at the ends of the cross-slides. The driving gear—arranged for 20 varying speeds—is placed at the right hand side of the machine. The feeding motions for the saddles and cutter-bars are obtained by means of friction disks, which admit of an infinite gradation from 0 to 1 in. in width per revolution of table. The amount of feed for each bar can be varied, stopped, or started without any reference whatever to that of the other bar.

This machine enables the Robert Poole & Son Company to do a class of heavy work which few or no other establishments in the country are prepared to undertake. It is also an excellent example of the heavy machine tools the enterprising Philadelphia firm is producing.

DELANEY'S COIL AND RING PACKING AND GASKETS.

The accompanying engravings represent the sectional ring and coil packing for piston and pump-rods, valve-stems, etc.

These are made by a process which, it is claimed, affords perfect lubrication, and it expands in such a way as to relieve the rods from all undue pressure. It is said to be extremely durable, and owing to the materials used and the method of manufacture, it is never burned or hardened while in use.

The lower engraving represents the man-hole gaskets of the same makers. These are said to form especially durable steam and water-tight joints, being made to stand a pressure of 300 lbs. These goods are manufactured by Messrs. H. J. Delaney & Company, Milwaukee, Wis.

STARRETT'S NEW TOOLS.

The accompanying engravings illustrate some new tools made by L. S. Starrett, of Athol, Mass. Fig. 1 is a universal surface gauge. It has the following improved features—viz., a joint at the base which allows the spindle and scriber to be moved back and forth and placed in any position from upright to horizontal to reach over, back of and under work that could not be got at with old-style gauges, while by inclining the spindle over the work its scope for long reach is increased.

The fine adjustment is nicely obtained by the knurled screw in the rocking bracket at the base acting against a stiff spring under the opposite end, while the joint above with the spindle may be set and rigidly held in any position desired. Two pins through the base, frictionally held, may be pushed

down by slight pressure to form a bearing to work from the edge of, or in the slots of the planer bed for lining up work, while the weight of the gauge against the bed with a little

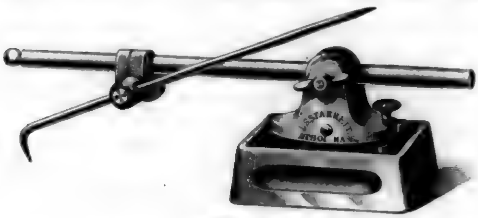


Fig. 1.

pressure is sufficient to push them back. Grooves around these pins, against which a pointed spring plunger presses, insure their being held in place either up or down. Concaved depressions milled in the sides of the base make it convenient for thumb and finger to grasp.

Fig. 2 is a similar tool of a smaller size and made on the same principle as the one shown in fig. 1. The base is steel nicely finished and *case-hardened*, with depressions milled in the sides for the thumb and finger to grasp. The top side of it is slotted, and the rocking bracket is pivoted in the same. There is a stiff spring under one end of the bracket and a knurled adjusting screw in the other; the spindle jointed to this may be set and rigidly held in any position from vertical to horizontal, and the scriber placed in position to be used below its base for depth gauge, or (with bent end down) a scribing gauge. It weighs but 11 oz., and is 5 in. high, and, folding the spindle (which is 4 in. long) horizontally over the base, it may be packed in 1⅝ in. × 1½ × 4 in. space in the tool chest.

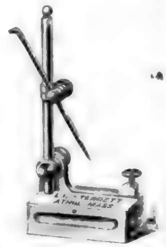


Fig. 2.

THE MAXON JACK.

We illustrate herewith a convenient form of locomotive jack, which is made by the McSherry Manufacturing Company, of Dayton, O. It has a height of 12 in. with a 6 in. lift, a capacity of 20 tons, and weighs 27 lbs. The screw is of steel 2 in. in diameter, and runs in an iron nut. The ratchet box, head and stand are of malleable iron.

General Notes.

At a recent fire of a cotton-press in Baltimore, Md., most efficient service was done by the fire-boat *Cataract*, which was built two years ago, and considerable attention was attracted to her by the work performed. She was built from the designs and under the superintendence of William Cowles, Constructing Engineer and Naval Architect, who is also President of the Cowles Engineering Company, which latter company furnished the Cowles water-tube boilers which supplies the steam for the engines and pumps of the *Cataract*.

The Riehle Brothers Testing Machine Company announce that beginning April 1 Mr. J. R. Matlack, Jr., will act as its representative at the World's Columbian Exposition, Chicago, and can be found, previous to the opening of the Exposition, at the Rookery Building, Chicago.

Staten Island Industries.—Messrs. J. B. King & Company, of New Brighton, are now putting into their extensive plaster mill a 1,000-H.P. condensing engine, built for them by Messrs. Watts & Campbell, of Newark, N. J. They have also added to their present boilers one large steel boiler, 200 H.P., built at the Starin Ship & Iron Works, Port Richmond.

The boilers, gas-burning furnaces, chimney and the entire system of underground flues connecting them were constructed under the designs and supervision of Mr. R. K. McMurray, a long-time resident of West Brighton, and Chief Inspector of the Hartford Steam Boiler Inspection and Insurance Company, of Hartford, Conn. Mr. McMurray also designed the large chimney, as well as all of the boilers of the Clark Thread Works, at Newark and East Newark.

The Sargent Company.—The name of the Congdon Brake Shoe Company has been changed to "The Sargent Company," and the business established under the former name, in 1876, confined at first to the introduction of the Congdon brake shoe, and developed since into a general brake shoe, iron and steel castings business, will hereafter be carried on under the latter name.

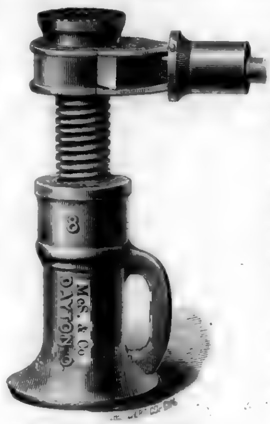
The Magnesia Sectional Covering Co., of 58 Warren Street, are issuing a set of very handsome steel engravings of the new United States cruisers, upon which their magnesia covering is used. The cards are elegantly printed, and are souvenirs well worthy of presentation.

The Johnson Railroad Signal Company have just closed a contract with the Chicago & Northern Pacific Railroad Company, E. J. Pearson Principal Assistant Engineer, for interlocking plant at Harvey, at the crossing of the Chicago Central, Chicago & Grand Trunk and Illinois Central railroads, 50 working levers.

Electric Car-Heater.—The Consolidated Car-Heating Company have brought out a new electric heater, of which they have sent us an elaborate description. Want of room has prevented its publication in this number of The American Engineer, but we expect to refer to it again in our next issue.

The Oliver Colborne Manufacturing Company, 59 East Indiana Street, Chicago, are working their force full time, keeping pace with the demand for the Tuttle gas-engine. This firm have recently fitted up their office in becoming style and greatly enlarged the output of their plant.

J. C. Drake Machine Works, Morgan and Jackson streets, Chicago, have been unusually busy in the manufacture of their clay crushers and brick-making machines. They are now some two months behind orders, and this fact suggests the prediction that brick manufacturers expect an unusually large demand for building material during the coming season around and in Chicago.



THE MAXON JACK.

The Diamond Machine Company, makers of grinding and polishing machinery, of Providence, R. I., has adopted for use in its exhibit at the World's Columbian Fair an illuminated sign, which will be of fine stained glass and wholly new in method of construction, for, in place of the unstable mounting of lead with the unsightly iron crossbars heretofore used, the glass is set in a durable cement between copper; the latter is "whole," as the spaces filled by the glass are cut out. Desirable and artistic effects are thus gained by the very varying lines or "masses" of copper never before attained under the old method. This new patented way of setting stained glass is owned by the Metallic Setting Company of Providence.

Raymond Brothers Impact Pulverizer Manufacturing Company, 271 South Jefferson Street, have just sold the National Oil & Paint Company a pulverizer to crush ore, from which they manufacture paint which the Union Pacific Railway use altogether. They have also put in a complete paint plant for the Chicago & Northwestern Railway at their 40th Street shops, this city. They report business exceedingly active. Raymond Brothers have just patented a new windmill, which besides from being lighter than any other style of wind-mill now manufactured, has less joints to break and the gearing is unexposed.

The Link-Belt Machinery Company recently closed a very large contract with Mr. J. C. Henderson, Engineer of the Milwaukee Street Railway Company, for a very extensive system of coal and ash handling machinery. The coal will be taken from wagons or barges in the river, at opposite end of building, and conveyed from either point to a system of coal bunkers, extending from first floor to ceiling of third

floor. From these bunkers the coal may be drawn to any one of the nine boilers located on either the first or second floor. The ash device is designed to receive from any one of the 18 boilers, delivering them to either one or two storage bins, from which they may be drawn into carts or barges to be carried away. This will make the most extensive system of coal and ash handling machinery erected in the West, and is in keeping with the magnificent new power plant of this company in Milwaukee.

The Ammonia Motor Again.—The Railway Ammonia Motor Company, which has offices in the Drexel Building, gave an exhibition of its system of running street cars recently. The motor this company uses was invented by P. J. McMahon, formerly a chief engineer in the navy.

The ammonia is first evaporated, and after the water has thus been removed from it, it is passed through a coil of pipes, over which cold water is sprayed. It is thus reduced to a liquid called anhydrous ammonia, which is collected in a big tank, from which it is drawn into a smaller tank on the car. This car tank is surrounded with an outer box containing hot water.

To generate the power the anhydrous ammonia is heated to about 80°, and as the liquid will boil in the air at 38¼° below zero, the heat develops a pressure of 150 lbs. This pressure works a piston in the same way as steam.

Enough ammonia can be stored on an ordinary car to run it for seventy miles over an average road. When one charge is exhausted another can be put in very quickly. Mr. McMahon reckoned the cost of running a car with his system at one cent a mile.

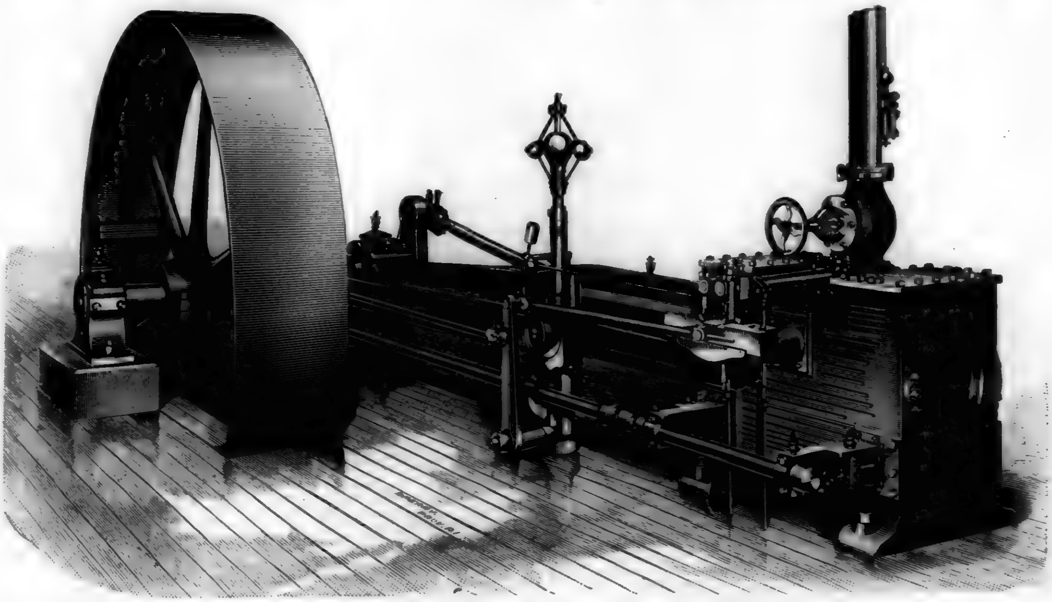
The sample car was taken out and run up and down a couple of blocks of the unused tracks on Twenty eighth Street, from Sixth Avenue west, in the experiments.

A Naphtha Cab.—A cab propelled by a petroleum-naphtha motor has been tried recently in Berlin. It is not a new invention, but was already seen at the Munich Exhibition in 1888. The firm which brought it out—the gas motor works of Benz & Company, in Mannheim—assert that they have made so many improvements that the cab is quite fit for practical use. The motor cabs are three-wheeled, and can carry only two persons, the driver included. Behind the seat is a sort of boot, which contains a petroleum-naphtha motor of nearly 2 H.P. The explosive mixture of petroleum, gas, and air, which is the moving power, is ignited by an electric apparatus. The inventors assert that on a good road a speed of about eleven miles an hour can be obtained. The price of such a cab is £250. It looks like a large two-seated bath chair.

THE IMPROVED GREENE ENGINE.

Our illustration represents a perspective view of the new improved Greene automatic cut-off engine, which is as it is built by the Providence Steam-Engine Company, of Providence, R. I.

The bed plate is of the girder pattern, symmetical in appearance, and of ample strength. The main journal-boxes are made in four pieces, and provided with set screws and check nuts, which permit of convenient and accurate adjustment. The governor is of the Porter pattern, and is driven by a flat belt from the main shaft. The valve-gear is detachable, and is so controlled by the governor that the cutting off may be effected from zero to three-quarters of the entire stroke. The valves are four in number—two steam and two exhaust—and are of the flat-slide pattern. The power which moves them is applied parallel to and in line with their seats, so that they cannot rock or twist—thus obviating the tendency to wear unevenly. The steam-valves when tripped are shut by a combined action of a weight and the pressure of the steam on the large valve-stems, thereby insuring a quick cut-off, and the positive closing of the port, under all circumstances of speed and pressure. The steam-valves are operated by toes, on the inner ends of two rock shafts that connect with the valve-stems outside the steam-chest. The outer ends of the rock-shafts are furnished with steel toes.



THE IMPROVED GREENE ENGINE.

There is a sliding bar carrying tappets which receives a reciprocating rectilinear motion from an eccentric on the main shaft. Below the sliding bar is a gauge-plate connected with the governor, which receives an up and down motion from a reverse action of the governor balls.

The tappets in the sliding bar are attached to the gauge-plate, and elevated or depressed in the bar by the action of the governor. As the sliding bar moves in the direction of the arrow, one of the tappets is brought in contact with the inner face of the toe on the rock-lever, causing it to turn on its axis, thereby opening the steam-valve at one end of the cylinder. At the same moment the other tappet comes in contact with the outer face of the other toe, and as the surfaces are beveled, the toe is forced up into the socket until the tappet passes under, when it drops by gravity alone into its original position, to be operated upon in its turn, when the motion of the sliding bar is reversed.

As a result of this motion, the tappets always give the valves the same lead, and as the bar moves in a straight line, while the toe describes the arc of a circle, the tappet will pass by and liberate the toe, which is brought back to its original position by a weight and the steam pressure on the large valve-

* LOCOMOTIVE RETURNS FOR THE MONTH OF DECEMBER, 1892.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Locomotive Mileage. Freight Trains.	Locomotive Mileage. Service and Switching.	Locomotive Mileage. Total.	Locomotive Mileage. Average per Engine.	Av. Train. Passenger Cars.	Av. Train. Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Coal Burned per Mile. Freight Train Mile.	Coal Burned per Mile. Service and Switching Mile.	Coal Burned per Mile. Train Mile, all Service.	Coal Burned per Mile. Passenger Car Mile.	Coal Burned per Mile. Freight Car Mile.	Cost per Locomotive Mile. Repairs.	Cost per Locomotive Mile. Fuel.	Cost per Locomotive Mile. Oil, Tallow and Waste.	Cost per Locomotive Mile. Other Accounts.	Cost per Locomotive Mile. Engineers and Firemen.	Cost per Locomotive Mile. Wiping, etc.	Cost per Locomotive Mile. Total.	Cost per Car Mile. Passenger.	Cost per Car Mile. Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Alabama, Great Southern																									
Alabama & Vicksburg																									
Atchison, Topeka & Santa Fé	834	730			387,071	2,289,931	3,099						91.91			5.65	7.54	0.26	6.17	6.87	1.54	22.03			1.58
Canadian Pacific	610		484,647	745,154	411,019	1,640,820	3,084						78.30			4.08	18.21	0.42		5.71	1.41	24.83			3.34
Chic., Burlington & Quincy	531					1,939,414	3,646	4.89	16.98				93.72			5.38	6.54	0.25	0.36	6.75		19.28			1.40
Chic., Milwaukee & St. Paul	820					2,781,026							79.23			3.96	8.10	0.27		6.81		19.14			2.00
Chic., Rock Island & Pacific	552		560,666	970,112	433,536	1,264,314	3,558						68.39			2.85	6.66	0.24	2.85	6.00	0.43	19.04			1.66
Chicago & Northwestern	868		707,331	1,484,896	741,916	2,934,120	3,304						93.62			3.51	9.12	0.36		6.36	0.84	20.19			1.98
Cincinnati Southern																									
Cumberland & Penn*	22	22	5,699	34,059		39,758	1,807						91.33			7.80	0.40		5.10		2.10	15.40			
Delaware, Lackawanna & W. Main L.	208	192				651,096	3,390						108.66			3.26	7.96	0.42		5.85					
Morris & Essex Division			174,738	243,496	12,507	430,761	2,726						72.91			5.16	11.29	0.39		6.27		23.11			3.07
Hannibal & St. Joseph	74					384,811	4,011	5.56	16.15				96.80	14.18	7.95	4.63	6.71	0.14	0.46	6.54		18.46			1.45
Kansas City, F. S. & Memphis	150		96,294	269,505	133,236	499,035	3,327						71.42			3.07	5.85	0.25	0.44	7.39		17.00			1.50
Kan. City, Mem. & Birm	41	37	37,093	63,923	14,090	115,106	3,111						65.89			3.28	3.79	0.24	0.35	6.88		14.64			1.10
Kan. City, St. Jo. & Council Bluffs		43	55,493	43,543	44,865	143,890	3,346	4.90	18.90				71.55	14.23	5.76	5.00	7.17	0.15	0.65	6.67		19.66			2.05
Lake Shore & Mich. Southern	584		446,617	885,097	589,840	1,921,554	3,278			68.65	91.40	40.61	71.81			3.71	5.60	0.12	0.06	6.96	0.19	16.64			1.56
Louisville & Nashville		350†	43[illegible],133	789,557	458,995	1,683,685	3,673	5.15	16.46	66.75	116.81	54.66	87.73	13.01	7.19	3.89	6.96	0.25	0.43	6.11	1.56	19.20	3.27	1.41	1.60
Manhattan Elevated		291	786,986		59,278	846,254							49.50			2.70	9.80	0.30		8.80		21.60			3.06
Mexican Central‡	140	114				416,208							76.27			3.88	17.01	0.48	0.30	5.29	0.84	27.68			5.43
Mil., L. S. & Western	112		78,768	144,151	72,355	295,274							86.56			3.70	12.06	0.24		6.30	0.94	23.23			2.80
Minn., St. Paul & Sault Ste. Marie			61,568	173,733	37,816	273,147		4.92	17.06				88.31			5.02	15.57	0.24		6.78		27.61		2.30	3.37
Missouri Pacific	330	303				1,152,675	3,801	4.55	16.96				95.14			5.67	6.90		1.66	6.51	1.57	28.33	4.16	1.64	1.43
Mobile & Ohio																									
N. O. and Northeastern																									
N. Y., Lake Erie & Western	618		462,007	966,941	293,678	1,722,626	3,160	4.50	23.06	89.01	144.9	78.00		10.06	6.07	4.45	8.10	0.37	2.46	7.33	1.14	23.81		1.70	1.37
N. Y., Pennsylvania & Ohio	253		135,775	447,793	148,907	732,475	3,450	5.40	17.04	78.01	194.2	73.90		14.06	7.01	4.03	5.91	0.31	2.15	6.57	1.09	20.36		1.74	1.12
Norfolk & Western, Gen. East. Div.†			100,236	269,557	53,870	423,663	2,922	4.07	18.09				106.38			8.50	3.80	0.70				13.00			
General Western Division†			70,751	236,206	25,719	332,676	2,683	4.06	15.00				131.57			16.60	4.60	0.80				23.00			
Ohio and Mississippi	100		139,388	140,298	87,173	366,853	3,365						88.88			3.52	3.20	0.21	1.66	5.46	1.41	16.00			0.81
Old Colony		224	365,772	233,758	33,457	632,987	2,781						64.18			3.36	13.03	0.69		5.76	0.81	23.58			3.75
Philadelphia & Reading			479,393	877,450	604,652	1,961,495							80.60			4.66	5.11	0.29		5.31	0.37	16.38			
Southern Pacific, Pacific System																									
Union Pacific	902		727,217	1,544,449	521,311	2,792,977	3,768	5.43	16.86				101.86			7.35	8.96	0.42	0.93	8.23	1.06	26.96	4.49	2.04	1.74
Vicksburg, S. & P.																									
Wabash	424	368	409,809	717,364	312,109	1,439,272	3,911			75.47	113.70	57.19	95.38	14.09	6.93	3.61	5.13	0.20		6.17	0.83	16.04	2.94	1.14	1.13
Wisconsin Central			136,839	224,986	60,129	421,954										4.56	11.38	0.28		7.20		28.41			2.35

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains 10 miles per hour.

† Wages of engineers and firemen not included in cost.

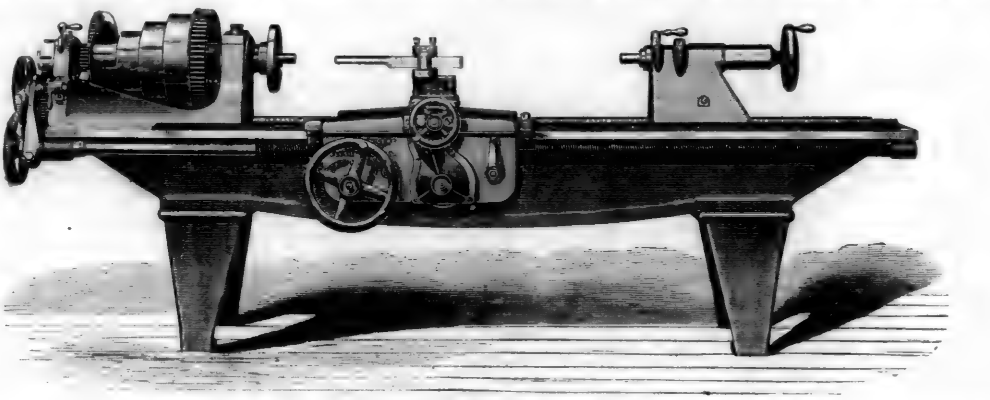
‡ Report for November, 1892.

stem, which thus closes the valve and cuts off the steam. The liberation of the toe will take place sooner or later, according to the elevation of the tappets—that is, the lower the tappets are, the sooner the toes will be liberated, and *vice versa*. By the elevation or depression of the gauge-plate, the period of closing the valves is changed, while the period of opening them remains the same. The adjustment of the gauge-plate is effected directly by the governor.

Both the exhaust-valves and seats are convenient of access, and removable from the outsider of cylinder. The valves receive their motion from a separate eccentric, thus allowing of easy adjustment, without interference with the steam-valve mechanism. All the connections are on the outside, are few in number, and have ample bearing surfaces, insuring freedom from rapid wear and derangement.

A safety stop-motion is combined with the governor, preventing the admission of steam should the governor belt run off or break.

The cross-head gibs are directly opposite the center of pin, thus avoiding any cross strain upon the piston-rod. The steam-ports are large, thus insuring the full pressure of steam to the point of cut-off. The engine is extremely sensitive to the action of the governor, and all parts are well proportioned, made of the best material, accurately fitted, and highly finished.



BOGERT'S IMPROVED 20-INCH ENGINE LATHE.

BOGERT'S IMPROVED 20-IN. ENGINE LATHE.

THE lathe illustrated is one made by John L. Bogert, of Flushing, N. Y., and has a swing over the top of the cross-slide of 14½ in., with length of bed of 10 ft. 8 in. The head stock has carefully fitted, adjustable boxes lined with the best phosphorized Babbitt metal. The front bearing is 3½ in. in diameter by 5½ in. long, and its cap is held down and adjusted by four ⅝-in. bolts. The live spindle is of very hard crucible steel, and has, unless otherwise ordered, a 1½ in. hole through its axis, carries a four-step cone for a 3½ in. double belt, and a front gear 14½ in. in diameter. Its end thrust is taken upon hardened tool steel collars with sides ground perfectly parallel. The ratio of the back gearing is 12 to 1, which, taken in connection with the diameters chosen for the corresponding steps of the overhead and main cones, makes the speed of rotation of the live spindle decrease in exact geometrical ratio from the fastest to the slowest. A very accessible rocking device on the back end of the head stock enables the direction of the feed to be instantly reversed without disturbing the change gears. The lead screw is 1$\frac{5}{16}$ in. in diameter, it cuts three threads to the inch, and is made as accurate in every way as is practically possible. The usual variety of threads from one to 16 per inch can be cut with the change gears without compounding. The thread of the lead screw is used only for screw cutting, the longitudinal and cross feeds being driven by means of a large key way or spline. The half nuts are opened and closed by one-third of a revolution of two single threaded screws of large diameter, and cannot fly open under any condition of feed strain. Both power feeds are frictional, and their engagement being by screws, slipping can at any time be prevented. All gearing of any description is cut from the solid, and the feed worm-gears are made of phosphor-bronze. The carriage is 33 in. long, gibbed for its whole length along the back shear, and at each end of the apron along the front shear. One of these latter gibbs is used to clamp the carriage when cross feeding. It is important to note the fact that the cross feed is made as coarse as the longitudinal feed, so that the feed-gearing rarely needs to be disturbed. The cross-slide, 20½ in. long, is fitted with one of Bogert's patent double screw tool posts. A telescopic slide by its movement protects the cross feed screw from chips in any position of the tool. The tail stock may be set over, to line the centers, and is clamped to the bed by two ⅞-in. bolts. The tail stock spindle is 2½ in. in diameter and 16½ in. long. The center rest will admit work from ⅜ in. to 9 in. in diameter without change of jaws. The follow rest is made either with adjustable jaws or with a split hole, to clamp bushings. Bogert's improved friction clutches and Bogert's improved method of oiling loose pulleys are features of the counter shaft. Counter-shaft pulleys, 15 in. in diameter and 4 in. face, should make from 160 to 180 revolutions per minute; the backing pulley should be run at least as fast as the latter speed for screw cutting. When the nature of the work makes it necessary or desirable, Bogert's improved elevating tool post or Bogert's improved compound rest may be applied to the top of the cross-slide, without any change in its construction. Tapers up to 4 in. to the foot can be readily and accurately turned with Bogert's improved taper turning attachment, without disturbing the alignment of the centers. This device must be provided for in the construction of the lathe. The bed, owing to a proper distribution of metal, is stiff and rigid, its design and arrangement of cross bracing being the result of the careful thought and experiment of years. In 1882 Mr. Bogert made the first drawing for a machine tool, with its bed deeper in the middle than at the end, and in 1885 tapered the ends, and at the same time brought the legs nearer together. His uniform practice in the case of lathes is to make the inside edge of the upper surface of one of the legs plumb with the front end of the head stock, and locate the other leg the same distance from the other end of the bed. An elliptic curve to the lower edge of the middle portion makes the elevation symmetrical, and best provides for the strain of use.

PROFESSOR LANGLEY'S AIR SHIP.

THE Washington *Post* of March 13 has published a long account of a "New Flying Machine," which it says Professor Samuel Pierpont Langley, of the Smithsonian Institute, has been secretly constructing and experimenting with for nearly two years. How much of this report is correct, and how much is a consequence of the exercise of reportorial imagination it is impossible now to know. The following abstract of this highly colored account is given for what it is worth:

"The machine is a working model. It is not intended to carry passengers. In configuration the body portion closely simulates a mackerel. The backbone is a light but very rigid tube of what is technically known as 'title metal,' one of the many alloys of aluminium and steel. It is 15 ft. in length and 3 in. in diameter. To give rigidity to the skeleton, longitudi-

nal ribs of stiff steel are provided, intersected at intervals by cross ribs of pure aluminium, the result being a lattice framework of great strength.

"The engines, which are located in the portion of the framework corresponding to the head of the fish, are of the double-oscillating type. They weigh 60 oz. and develop 1 H.P., the lightest of that power ever made. There are four boilers of thinly hammered copper weighing a little more than 7 lbs. each, and they occupy the middle portion of the fish. Instead of water, a very volatile hydrocarbon is employed, the exact nature of which is a matter of secrecy, but which vaporizes at a comparatively low temperature. The fuel used is refined gasoline, and the extreme end of the tail of the fish is utilized for a storage tank with a capacity of one quart. Before passing on to the boilers the gasoline is volatilized by going through a heated coil.

"There are twin-screw propellers, which would be made adjustable to different angles in practice, to provide for the steering, but which in simply a working model are necessarily fixed at a certain point for a given trial. Screws of various pitches, and ranging from 20 to 80 centimeters in diameter, have been experimented with, but it is not yet definitely determined which shall be adopted for trial. With the smallest, the engines develop a speed of 1,700 revolutions a minute. With the larger ones the speed is somewhat decreased.

"A thin jacket of asbestos covers the upper portion of the body of the fish. It is unusually porous, and probably is employed to prevent undue loss of heat by radiation. The wings or aeroplanes are sector shaped, and consist of light frames of tubular aluminium steel, covered with China silk. The front one is 42 in. wide in the widest part and has an extreme length of 40 ft. from tip to tip. The rear one is somewhat smaller. Both aeroplanes are designed to be adjustable with reference to the angle they present to the air. A tubular mast extends upwardly and downwardly through about the middle of the craft, and from its extremities run stays of aluminium wire to the tips of the aeroplanes and the ends of the tubular backbone, and by this trussing arrangement the whole structure is rendered exceedingly stiff.

"The machine was constructed and perfected to its present degree in a secret room in the Smithsonian Institute, where it now rests. It was conceived about twenty months ago by Professor Langley, who associated with him in the work of experimentation Chief Clerk W. C. Winlock and Dr. Kidder, a scientific expert employed at that time in the institution. Four skilled workmen in mechanics and metallurgy were put to work under pledge of secrecy. The work went on at odd hours, mostly at night and on Sundays.

"An out-door trial has been planned. The intention is to employ a tug to tow the experimental party to a creek about 45 miles down the Potomac, where the experiments may be conducted without fear of interruption.

"In the large lecture-room of the National Museum Professor Langley has succeeded repeatedly in producing successful flight by small models. They would fly as long as the power lasted, the power being applied by means of lightly wrapped rubber bands, on the principle of the string top. The lightest of these little models weighs 16 grammes, and will soar from one end of the room to the other as freely as a bird.

"Professor Langley went to France, and while in touch with the most advanced investigators there he is believed to have reached his conclusion as to the best model for the general conformation of the proposed air craft—namely, the long, thin, tapering lines of the mackerel."

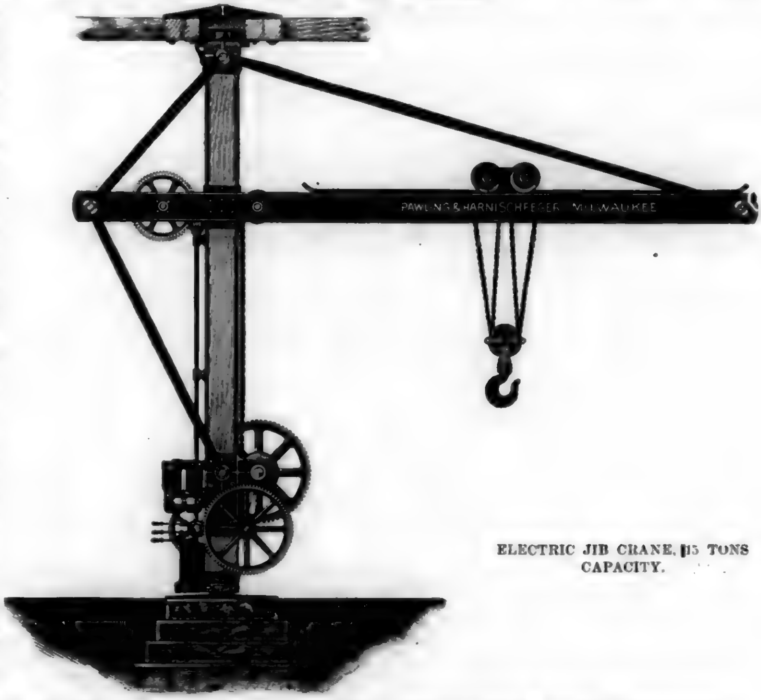
[There is a fishy flavor about this account which is disturbing to one's credulity.—Editor American Engineer.]

A NEW SHOP CRANE.

The accompanying illustration shows a jib crane of excellent design, made by Messrs. Pawling & Harnischfeger, of Milwaukee, Wis. This crane has a capacity of 15 tons; it has a clear lift of 18 ft. and a radial swing of 21 ft., enabling it to cover a floor space 42 ft. in diameter, or nearly 1,400 sq. ft. of floor. The jib is composed of two 20-in. steel beams, and the heaviest steel eye-bars forming the tension members have a net section of 4 sq. in. each, and receive a maximum stress of less than 15,000 lbs. per square inch. All the gears are cut from solid metal, and the pinions, in all cases, are cut from the best grade of machinery steel, thus insuring strength, durability and safety.

The shops of this firm have several of these cranes under construction for shops and foundries in Milwaukee and elsewhere, besides several of similar pattern and smaller capacity.

These works have also just shipped the first of three large armature lathes for the Siemens & Halske Company. These are specially designed for turning and finishing armatures from 10 to 16 ft. in diameter.



ELECTRIC JIB CRANE, 15 TONS CAPACITY.

AUSTIN LOCOMOTIVE STONE BREAKER.

Mr. A. B. Austin, of Fort Wayne, Ind., has recently put upon the market a locomotive stone breaker, which is intended to break stone along the track and deposit it in the form of ballast where it is needed. It is arranged with a single pair of drivers, which gives it the necessary adhesion for not only moving itself, but also for hauling one loaded car. It will run 30 miles an hour, and is so arranged that it can be changed from a locomotive to a stone breaker in five seconds by raising the drivers off the track, and it is guaranteed to break from 25 to 30 cubic yards of stone per hour on the main track or in the quarry. The rock for ballast can be handled in large lumps, loaded on flat cars, and drawn to the place where it is to be used as ballast.

The method of operation is to load and distribute this heavy rock along the side of the track where it is needed, and then take the machine to the spot and throw the large pieces into the breaker, thus doing away with the necessity of handling the broken stone with shovels. When in use the driving-wheels become the fly-wheels of the engine, and give the requisite steadiness of motion to the crusher. It would seem that there are many places in which such a machine would prove valuable and efficient.

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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NEW YORK, MAY, 1893.

IN our April issue there was a typographical error in the solution of the "Locomotive Problem," by C. H. Lindenberger. The diameter of the drivers should have been 7 ft. instead of 8 ft., as given.

EDITORIAL NOTES.

THE latest report regarding the annual coal production of the world credits the United States with an output of 140,000,000 gross tons, with Germany second with 90,000,000 gross tons, and Great Britain third with 85,000,000 gross tons. At the same time there has been a slight advance in the average price.

IT is said that American pig irons are gradually displacing the English and Scotch products in Central and Western Canada. At Montreal, where the foreign irons are landed, they have the advantage in price, but when the cost of land transportation is added, it becomes impossible to sell it in competition with American iron made in Ohio and Pennsylvania.

THE report is in circulation that Professor Elisha Gray's new telautograph has been tested by experts in New York and Chicago, and that they are full of enthusiasm over its possibilities. The action of the instrument is the reproduction at the receiving end of the wire of any figure or writing that is drawn on a piece of paper with a pen at the sending end.

THE daily papers are continuing their hue and cry regarding the refusal of the railroads to give greater reduction of fares to Chicago, on the plea that the present rates will deprive hosts of people of the pleasure of the trip, and yet the people of Chicago, by the extortionate rates which they propose to charge for rooms and hotel accommodations, are doing their very best to deter the public from visiting the city.

A FEW years ago there was considerable discussion relative to the possibility of an 18-hour train between New York and Chicago. A rumor is abroad that this is about to be approached by a 19-hour express over the New York Central & Hudson River Railroad. The long success of the Empire State Express in making schedule time between New York and Buffalo has led to the decision to maintain the same speed with a similar train on to Chicago.

A NEW department is being added at the Superior hard ore mines. For some time the soft high-grade ores have been crowding the hard ores out of the market, because the former came to the furnaces ready for smelting, while the latter had to be crushed. Lately crushers have been added to the plant at the mines, and the result has been that while there is some additional expense to the mine owners, the increase in their orders more than compensates them for the extra labor involved.

THE "Good Roads" movement seems to have gained a firm footing in many parts of the country, and the probabilities are that before long the work of improvement will be begun. Governor Flower, of New York, has already signed a bill which authorizes the warden of Clinton Prison to employ the convicts in road making within a radius of twenty miles of the prison, and if the attempt is successful the same authority will probably be extended to the wardens of the other prisons of the State.

OUR pages are a cotemporary chronicle of the advancement that is being made in the shipping interests of the great lakes. There is hardly a month but that some new vessel is projected or launched, until now they have come to assume the dimensions of the best of the Atlantic liners of a few years back. This advancement was brought out very prominently at a dinner given in Duluth, where Mr. James J. Hill, President of the Great Northern Railway, stated that his Company is building two steamers capable of carrying 350 first-class passengers, and of making the trip from Buffalo to Duluth, a distance of 1,000 miles, in 50 hours, adding, in conclusion, his belief that this would result in the establishment of a daily line.

BOILER TUBES.

FOR some months past, or perhaps it may be said for several years, English engineering journals have contained many articles, papers, and much correspondence on the subject of boiler tubes, the chief burden of which is the difficulty of keeping marine boiler tubes from leaking, especially when forced draft is used. One effect of the trouble, a correspondent intimates, is that many of the engineer officers in the British Navy are getting *bald*. It is not surprising, therefore, that the subject of boiler tubes is attracting much attention at present.

It has never been satisfactorily explained why this difficulty is so much more serious in marine boilers than it is in locomotives, or, in other words, why locomotive tubes can be kept tight and those in marine boilers cannot. *Engineering* of February 24 contained a long editorial article, in which the whole subject was summed up, or, rather, the evidence re-

lating to it. The difficulty is attributed to a variety of causes, and many cures have been proposed. One correspondent points out that the difference in temperature between the inner and outer surfaces of the tube-plate causes the latter to become convex toward the fire, and he advocates the use of thin tube-plates. Other correspondents predict that thin tube-plates will not stand long service, whereas Mr. Yarrow recommends thin tube-plates, and says there is no difficulty from their want of strength, and that they may be sufficiently stayed by the tubes alone, even when these become leaky.

There has been a good deal of conjecture with reference to the question whether the tube-holes are contracted or expanded by heat in ordinary service. One correspondent asserts that the *cause* of tube leakage is the transverse compression of the tube by the "nip" due to the expansion of the overheated tube in the plate—that is, the expansive action of the heat produces a permanent set in that portion of the tube inside of the hole in the plate, and when the tube is cooled and contracted, it becomes smaller than the hole, and consequently leaky. The same correspondent says: "The cause of the delay in improvement has, in my opinion, certainly been due to the fact that nearly all effort has been in the direction of improving the joint and in reducing mechanically the strain on the tube-plate, while it should have been aimed at an improvement in the circulation past the tube-plate and fire-box stays." He proposes as a remedy for the evil a system of circulating plates and a "helical fan," or a sort of screw working in a tube in the boiler, and driven by a light engine outside, so as to force the water past the tube-plate and fire-box sides.

On the other hand, Mr. A. J. Durston, Engineer-in-Chief of the British Navy, does not look for salvation in thin tube-plates, or, as *Engineering* says: "His contention is that all trouble comes from overheating; that, be tube-plates thick or thin, tube ends will leak if the evaporation be rapid, unless circulation of water against the tube-plate be unobstructed. He has recently read a paper before the Institution of Naval Architects on Some Experiments on the Transmission of Heat Through Tube-plates, in which are reported a variety of experiments and investigations bearing upon this subject, and to which reference will be made later on. Other disputants also attribute the difficulty to a want of circulation.

The arrangement of tubes in vertical and in horizontal rows has also been discussed, and some correspondents claim to have realized much advantage from arranging them in horizontal instead of vertical rows. It should, perhaps, be explained that to lay off tubes in horizontal rows a radius equal to the distance between the centers of adjacent tubes is taken. With this radius describe a circle. Its center will be the center of one tube. Then draw a horizontal line through the center of the circle. The intersections with the circumference will be the centers of other tubes, which will be in a horizontal row. With the radius of the circle and from the points of intersection subdivide the circumference into equal parts. The points of subdivision will be centers of more tubes, which will be in horizontal rows. To lay them off in vertical rows, proceed as explained, but draw a vertical instead of a horizontal line through the center of the circle.

Whether the favorable results which were claimed were due to the horizontal arrangement is, however, disputed.

Another plan for promoting circulation which has been proposed is to direct the feed water across the surface of the tube-plate, thereby inducing a current; but the good effects of this are also disputed.

A variety of circulating plates in boilers, arranged in different ways, but having the common object of dividing the ascending from the descending currents, has been suggested.

Various methods of protecting the tube ends by ferrules have been tried. These are made of different materials, malleable cast iron being perhaps the most satisfactory. A composition of plumbago, ganister, and fire-clay, and plastering the tube-plate or protecting it with fire-tiles have been experimented with; all of these are intended to act on the principle of reducing the transmission of heat through the tube-plate and tube ends.

There seems to be a very general unanimity of opinion that greater care and better workmanship is required in fastening tubes. Mr. Yarrow showed the evil effects of driving a tapered mandrel into a tube fitted into a parallel hole. The editor of *Engineering* says, with reference to this point—and we think all good mechanics will agree with him—that "a point of considerable importance is that the tubes should be free from rust or scale at the points where they come in contact with the tube-plates. In the case of iron or steel tubes these portions of the external surfaces should be thoroughly cleaned, either by grinding or filing, prior to the tubes being inserted, and that, moreover, every care should be taken to prevent the parts so cleaned from becoming rusty prior to the tubes being actually fixed."

In *Engineering's* article there is no reference made to the use of copper ferrules between the tube ends and tube-plate. It is, we believe, the general experience of nearly all locomotive superintendents in this country that it is difficult to keep iron tubes tight without using such ferrules. There is nothing said, either, about the fact that the tubes must expand more than the shell of the boiler, owing to the heat coming in direct contact with them. This surely must have a very considerable effect on the joints of the tubes in the tube-plate.

The discussion calls to mind that old historical one of whether a pail of water would weigh more with a fish in it than it would without. As a matter of fact, we are very ignorant of what occurs in the inside of a boiler; and if it were possible to get a good view of what takes place in, say, a locomotive boiler when a rapid rate of combustion is going on in the fire-box, it would probably increase our knowledge very materially. It does not seem impossible to illuminate the whole interior of such a boiler with electric lights, so that every part would be visible, and could be photographed through openings properly protected with glass. To use a feminine expression, it makes one "ache with curiosity" to get a view of that kind.

The paper on The Transmission of Heat Through Tube-plates, referred to above, which we regret we have not room enough to reprint in our pages, is to a great extent a report of investigations intended to throw light on this imperfectly understood subject. We can give only the briefest abstract of the results of these investigations.

It was found, first, that the temperature of the hot side of a clean plate ½ in. thick through which heat is passing to boiling water was about 240° F. Next, it was shown that with a coating of grease, obtained from the inside of a boiler, on the water side of the plate the temperature on the other side was about 330° F. Both experiments were made over a Bunsen burner.

To ascertain the temperature at the center of its thickness

of a plate ¾ in. thick, resembling a boiler tube-plate exposed to a forced blast fire, holes were drilled in the center of the thickness of the plate in a direction radial to the tube hole. These holes were filled with square pieces of fusible alloys. The temperature of the fire was about 2,000°, and the alloys whose fusing temperature was 290° were melted, but those which would melt at 336° were not.

To determine the temperature of the tube-plate at which injurious overheating—*i e.*, such as to cause leaky tubes—takes place, a boiler with brass, steel and iron tubes was constructed, and was then heated to a temperature of 630°, at which lead melted. On being tested afterward to a pressure of 200 lbs. to the square inch, the tubes were found to be practically tight. On heating it to a temperature at which zinc melted—750°—two of the brass tubes split, and it was found necessary to roll two other brass tubes. On being tested again with 200 lbs. pressure, a few of the brass and steel tubes leaked slightly, the iron tubes being without a weep. After being heated so that the tube-plate showed a red heat—about 1,400°—the boiler, on being tested with water, all the tubes leaked so badly that no pressure could be maintained. It was, therefore, inferred that a tube-plate, to be overheated sufficiently to make tube joints leak to an appreciable extent, must be raised at least to the temperature of melting zinc—viz., 750°.

Experiments were made which showed that the loss of efficiency of the heating surface of tubes in a boiler due to a thin coating of grease deposit was from 8 to 15 per cent., the mean of many experiments giving 11 per cent.

The temperature of plates when boiling water under various conditions at a higher temperature than 212° was found to be as shown in the following table :

	Temperature of Hot Side of Plate.	Temperature of Water.	Difference.
	Fah deg.	Fah. deg.	Fah. deg.
Over Bunsen burner	430	363	67
Over blast forge (full blast)	430	344.5	85.5
Over forge fire—grease deposit 1/16 of an in. thick	510	359	151
Do., but using grease of drier or earthier nature	550	351	199
Do., and spreading the grease up the sides of the vessel as well	617	80	537

Experiments on the behavior of tubes of various materials showed that brass and copper tubes leaked even when the plate was below the temperature of melting lead—617°—showing that these materials did not stand as well as iron and steel.

It was not found that at the higher pressures there was any marked addition to the excess of temperature of the hot side of a plate over that of the boiling water.

Experiments were made to determine the temperature of the center of the thickness of a tube-plate with an experimental boiler working with closed ash-pits and moderate air pressure. To do this, holes were drilled in the middle of the plate in a radial direction from the inside of the tube hole, and various alloys with different melting temperatures were inserted. With a temperature of 3,100° in the combustion chamber, the temperature in the middle of the plate rose to 530°, but was less than 540°.

Further experiments were made to ascertain the temperature of the fire side and middle of thickness of tube-plate in experimental boiler with forced draft and closed stoke holes. With temperatures in the combustion chamber varying from 2,500° to 3,200°, the temperature at face of plate was 1,060°, and at middle of plate was between 680° and 750°.

It was shown, by another series of trials to determine the behavior of Lowmoor iron *versus* steel tubes as regards leakage in the experimental boiler, that the former are at least not superior to steel ones ; and as the latter, it is said, will stand more rolling than the ordinary iron tube of commerce, it seems to justify a preference for steel tubes.

Of these trials it is said that the "first trial was of five hours' duration with 3-in. air pressure. No leakage of tubes occurred at this trial. Second trial of five hours' duration with 3-in. air pressure for first two hours and 3¼ in. for next three hours. At the conclusion of this trial the fan was kept going for some time after drawing the fire, *but no leakage of tubes occurred.* Attention is called to this fact, as great stress is frequently laid on the action of cold currents of air in producing leaky tubes."

After this trial mineral oil was introduced into the boiler, and leakage then soon commenced. The experimental boiler, although subjected to the high temperature of about 3,000° in the combustion chamber and 1,600° in the smoke-box, and further subjected to hard treatment by admission of cold air through the tubes after drawing the fire at the conclusion of the second trial, did not leak till grease was used in it.

To determine the temperature at various parts of the tubes of an ordinary marine boiler, a series of experiments was made. The boiler had two furnaces and 166 tubes 2¼ in. external diameter and 6 ft. 8 in. long, the consumption of coal being about 17 lbs. per square foot of grate. The following are the mean results of eight sets of records :

	Deg. Fah.
Temperature in combustion chamber	1,644
" just inside tube	1,550
" in tube 1 in. from combustion chamber	1,466
" " 2 in. " "	1,492
" " 3 in. " "	1,405
" " 4 in. " "	1,412
" " 5 in. " "	1,398
" " 6 in. " "	1,406
" " 7 in. " "	1,400
" " 8 in. " "	1,410
" " 1 ft. 2 in. " "	1,368
" " 1 ft. 8 in. " "	1,295
" " 2 ft. 8 in. " "	1,198
" " 3 ft. 8 in. " "	1,106
" " 4 ft. 8 in. " "	1,015
" " 5 ft. 8 in. " "	926
" " 6 ft. 8 in. " "	887
" in smoke-box	782

In commenting on these tests, the author of the paper says that they show "that even beyond 6 ft. in length there is an appreciable transfer of heat. If this is the case with a boiler burning only 17 lbs. of coal per square foot of grate per hour, it would be interesting to know how much heat is transferred to the water through the front ends of locomotive tubes when from 100 to 200 lbs. of coal are burned in the same time.

The experiments summarized above concluded those made on a small scale. Others on a larger scale were made on shipboard, with the object of avoiding leakage of boiler tubes. It is remarked in the paper that considerable trouble has been experienced with leakage of tubes in the double-ended common combustion chamber boilers and those of the locomotive type. Various expedients were tried in some of the boilers to overcome the leakage. These were as follows : "Rolling tubes with a shoulder inside the tube-plate ; beading tubes over the tube-plate ; rolling the tubes parallel ; fitting ordinary ferrules in tubes ; shortening the grates, involving an increase in the air pressure ; replacing the stays from the top of the combustion chamber to the shell of the boiler by dog stays having no connection with

the top of the boiler. No definitely beneficial results," it is said, "have attended any of these measures. The modification in those boilers that gave the greatest benefit was

Fig. 3. Fig. 2.

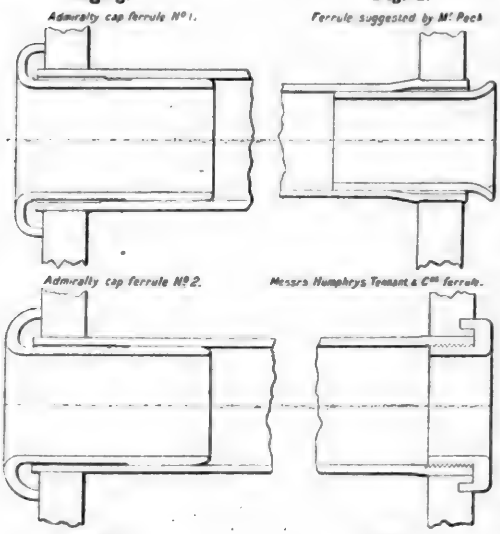


Fig. 4. Fig. 1.

that of removing two vertical rows of tubes over the center of each furnace." It is said, further:

"Concurrently with the efforts that were being made to overcome the leaky tube troubles by improving the circulation, experimental trials were being conducted in the locomotive boilers of the torpedo gunboat class (1) by plastering the tube-plate with a non-conducting composition, thus protecting it on the fire side; and (2) by ferruling the tubes with fire-clay cap ferrules, the caps of which afforded protection to the tube ends and the larger part of the tube-plate. The object of these experiments was not to demonstrate the effectiveness of the materials used, but to show whether the leakages of boiler tubes were not due to the overheating of the tube-plate and ends. This was established, for as long as, in the first case, the cement adhered, and in the second case the ferrules lasted, leakages did not occur. They were, however, both liable to rapid destruction, and could not be relied on as a permanent protection."

The report goes on to say:

"Among the first of the practical suggestions made for ferruling the tube ends was that patented by Messrs. Humphrys, Tennant & Company, and illustrated by fig. 1. It will be seen that this ferrule is screwed into the tube at the fire-box end, and that the cap fits into an annular recess cut in the tube-plate. The principle of this ferrule is that when a contraction in diameter takes place, due to variations of temperature, the outer part of the ferrule tends to tighten upon the concentric portion of the tube-plate. Further, as the ferrule is screwed into the tube, it has the advantage of the holding power afforded by the rolling of the tube into the cooler smoke-box tube-plate. It will also be seen that from its construction it provides a large amount of jointing surface, and an intricate passage to prevent the escape of water. On the other hand, it has the disadvantage that ferrules cannot be withdrawn for cleaning and repairs, but must be cut out, and it is somewhat costly in fitting."

These ferrules were fitted into the tubes of the boilers of the *Medea*, and during her trial gave good results.

Fig. 2 shows a ferrule proposed by Mr. Peck, of Messrs. Yarrows' firm. In this the tube ferrule, or protector, does not touch the tube where it is fixed in the tube-plate, but is in contact with the tube only at a part where all its heat may be readily absorbed.

Fig. 3 was proposed by Mr. Oram, engineer inspector, and in addition to the features embodied in Mr. Peck's ferrule it has a cap to protect the tube end and the greater part of the fire-box tube-plate from direct contact with the products of combustion. Experience resulted in the shape of ferrule shown in fig. 4. To make a practical test, these ferrules were fitted in the *Barracouta's* boilers. The port boiler was fitted with wrought-steel ferrules, and the starboard boiler partly with the same, and partly with malleable cast-iron ones. Very complete trials of the boilers were then made with satisfactory results. It was noticed that the scaling of the malleable cast-iron ferrules appeared to be much less than that of the wrought steel.

After this test of the ferrules they were fitted into the boilers of the *Thunderer* and thoroughly tested, also with satisfactory results.

This interesting paper ends by saying:

"These cap ferrules have been fitted to several other ships having various types of boilers with satisfactory results, and requests for them are being made by ships of the fleet, with the view of protecting the tube-plates and ends from overheating. Whether by want of circulation, excessive temperature in the combustion chamber, or from the presence of grease or solid matter, it is submitted these cap ferrules have fully answered their intended purpose."

From the testimony which has been quoted it might be inferred that the leakage of marine boilers is due chiefly to the overheating of the tube-plates, which is a consequence of either defective circulation or the presence of grease in the boiler. If this is the true reason, it is a curious fact that there is so much less trouble from leaky tubes in locomotive boilers, where the fire-box temperature must be much higher and where the circulation of water can hardly be as good as in marine boilers.

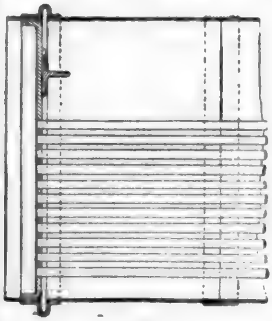


Fig. 5.

Furthermore, the author of the paper from which we have quoted so liberally expresses the opinion that the method of fastening tubes in the plate seems to have little influence on their tightness. The experience of locomotive superintendents and master mechanics in this country, we think, would not confirm this deduction. The great preponderance of practice here with iron and steel locomotive tubes is that it is of the utmost importance that they should have copper ferrules between the tube end and tube-plate at the fire-box end, and should be beaded inside the fire-box tube-plate and turned over on the outside—in other words, that the method of fastening is of the utmost importance.

It is curious, too, that there is no reference in the paper to the effect of the difference in expansion of the tubes and

the shell of the boiler. It is a very common impression that long locomotive tubes are much more difficult to keep tight than short ones. The breakage of stay-bolts is often attributed to the expansive action of the tubes. A recent number of the *Railway Engineer* contains a description of a method of construction of locomotive boilers intended to overcome this difficulty. This is shown in figs. 5 and 6. It has been patented by Mr. Martin Atock, M.Inst.C.E.I., Locomotive Superintendent of the Midland Great Western Railway of Ireland, to allow a locomotive boiler to "breathe" freely.

In describing it the *Railway Engineer* says:

"The difference between the expansion of the brass or copper tubes and the iron and steel shell of a locomotive boiler is well known, and Mr. Atock drew attention to the evils which are chargeable to this cause in a paper which he read before the Inst. C. E. of Ireland in April, 1882. Soon afterward Mr. Atock had a boiler fitted up as an experiment with a single bowling-iron expansion ring, as shown at fig. 5, and it worked most successfully for seven years, when the constant working or "breathing" caused grooving to take place at *A*, and a new ring had to be put in.

"In order to minimize the grooving Mr. Atock put in three corrugations, as shown at fig. 6, and these give every indication of lasting the life of the boiler. The flexible tube-plate or corrugated front end ring has the advantage of throwing a less strain on the tubes, as in the latter case they have only the tube-plate to move forward, whereas in the former they have the entire weight of the boiler to thrust backward.

"There are now 27 engines running on the Midland Great Western Railway having their boilers fitted as shown at fig. 6. The first of these engines commenced running in November, 1889, and has accomplished 118,000 train miles, and has given every satisfaction up to the present time. An invention of this kind of course requires a period of years to thoroughly test it, but there is every indication that it will result in a saving of both tubes and tube-plates, to say nothing of the inconvenience of the delays resulting from tube failures and leakages. The corrugations may be either wholly inside the shell or outside, and in the former case the ordinary construction of the shell is not interfered with at all.

"Some idea of the strains which are thrown upon locomotive boilers by the variations of the temperature may be gathered from some careful experiments made by Mr. Atock. In a boiler 10 ft. long between the tube-plates the brass tubes lengthen ⅛ in. more than the shell of the boiler does when raised in temperature from 60° F. to 212° F., and this movement takes place every time steam is got up or let down. When steam is up to 150 lbs. per square inch, but the engine not at work, the tubes lengthen ⅜ in. bare and an additional ⅛ in. full when the engine is working hard, thus making a total of ½ in. Under the same conditions the boiler shell expands only ¼ in. bare, so that there is a movement of ¼ in., which must take place, and is, with the flush-topped boilers quite unprovided for, and results in the distortion of tube-plates and grooving near the flange of the front tube-plate, breaking off of the ends of tubes near the tube-plates, and the tubes give trouble by working themselves loose and consequently leaking."

It is of course true that the difference in the expansion of brass or copper tubes and the shell of the boiler is greater than that of iron or steel tubes, but owing to the fact that the products of combustion come in contact with the tubes before the water is even warmed, and never comes in contact with the boiler shell, it must be obvious that the expansion of the tubes must be considerably greater than that of the boiler shell.

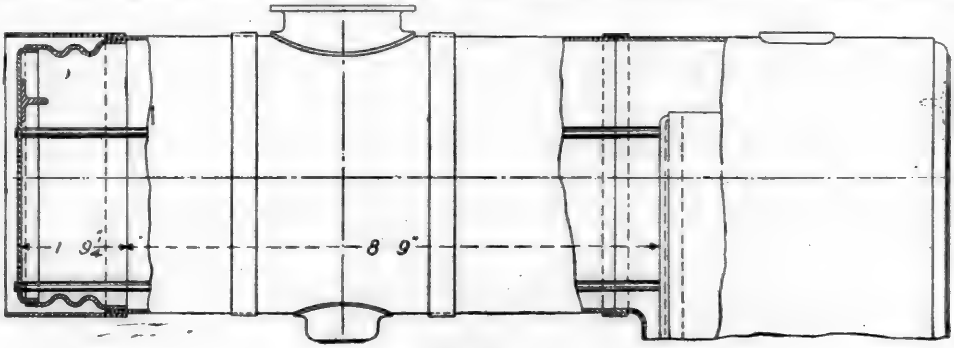


Fig. 6.
ATOCK'S PATENT ELASTIC BOILER BARREL.

"Mr. Atock does not use longitudinal or gusset stays, but stiffens the flat portions of the end plates with girders, as shown.

"Mr. Atock's experiment fully bears out Mr. Yarrow's well-known researches with torpedo-boat boilers of the locomotive type. The invariable deductions from Mr. Yarrow's investigations were that the boilers worked under a forced draft required much more freedom to expand than was ever allowed, at least in the Navy."

The first requisite for keeping tubes tight would seem to be to protect them from undue strain from longitudinal expansion.

The second, good workmanship in fastening them in the tube-plate. If any one should try to make a steam-tight joint in, say, a steam-chest cover, and should not finish the surfaces true and smooth, any good mechanic would jeer at him, and yet it is the common practice to fasten tubes in tube-plates with the scale on the ends of the tubes, or if it is removed, it is done by hand, and they are merely roughly filed. That it is impossible to do a good job with such work is not surprising.

The third, protection to the ends of the tubes from overheating by keeping the boiler clean, promoting circulation, and protecting the ends with ferrules such as have been found efficacious in the British Navy.

BOOKS RECEIVED.

The Practical Engineer. Pocket-book and Diary, 1893. Edited by W. H. Fowler. Technical Publishing Company, Manchester, England.

The Measurement of Electric Currents. By James Swinburne, M. Inst. E. E., and C. H. Wordingham, Assoc. M. Inst. E. E. Edited by T. Commenford Martin. Van Nostrand's Science Series, New York.

Infantry Drill Regulations, United States Army. Army and Navy Journal, New York.

Manual of Guard Duty, United States Army. Army and Navy Journal, New York.

Switch Layouts and Curve Easements. By Augustus Torrey. The Railroad Gazette, New York.

Electrical Measurements and other Advanced Primers of Electricity. By Edwin J. Houston, A.M. The W. J. Johnston Company, Limited, New York.

Triangular Surveys from Single Stations. By Augustus Knudsen, C.E. Brunt & Company, San Francisco, Cal.

Professional Papers of the Corps of Royal Engineers. Edited by Captain W. A. Gale, R.E. Royal Engineers Institute. Occasional Papers. Chatham, England.

ELECTRIC LOCOMOTIVE.

We give a perspective view of an electric locomotive which is being built for the Baltimore & Ohio Railroad Company, to be used in the Baltimore tunnel. The engine is to weigh 90 tons. As the drawing comes to us just as we go to press we are unable to give any further details of its construction in this issue.

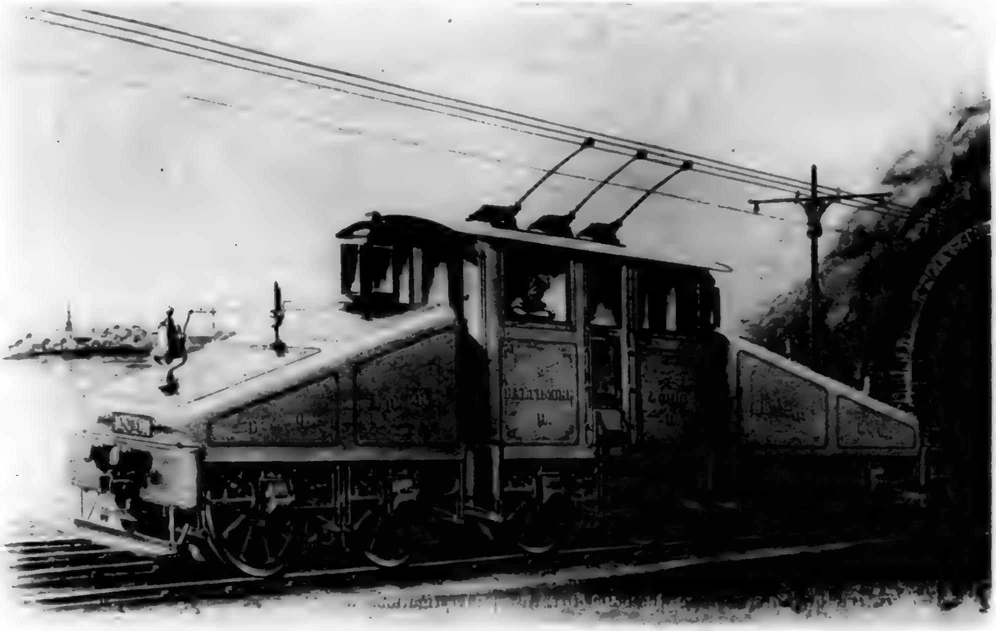
THE "JOHN BULL."

The Pennsylvania Railroad Company issued invitations recently which read as follows:

"The original *John Bull* locomotive and train of cars will run from New York to Chicago, over the Pennsylvania Railroad, April 17–22, 1893. Mr. ——, you are respectfully invited to accompany the party from —— to ——.

"George W. Boyd,
"*Assistant General Passenger Agent.*"

On the back of the card was published a schedule of the



90-TON ELECTRIC LOCOMOTIVE, BALTIMORE & OHIO RAILROAD.

Sewage Treatment and Sludge Disposal. By W. Santo Crimp. R. J. Bush, London.

Rules and Regulations Governing Freight Traffic. By Alfred L. Frazer. New York (Press of Gelhaar, Fleming & Fuller, Rochester, N. Y.).

Manual of Irrigation Engineering. By Herbert M. Wilson, C.E. John Wiley & Sons, New York.

Transactions of the American Institute of Electrical Engineers: Volume IX. Published by the Institute, New York.

American Railroads as Investments. A Handbook for Investors in American Railroad Securities. By S. F. Van Oss. G. P. Putnam's Sons, New York.

Municipal Improvements. A Manual of the Methods, Utility, and Cost of Public Improvements for the Municipal Officers. By W. F. Goodhue, C. E. John Wiley & Sons, New York.

John Bull train from New York to Chicago. The leaving time from New York was 10 A.M., April 17, and the time of arrival at Chicago was 3.30 P.M. on April 22.

At the time appointed a goodly company, consisting largely of newspaper men, assembled in the station of the Pennsylvania Railroad in Jersey City. The train consisted of two of the old cars and the veritable *John Bull*, which had been put into running condition recently. The engineer was Albert Herbert, who ran the engine in 1847. The conductor was W. T. Bailey, who began his career as conductor on the old Camden & Amboy Road in 1858, and had been in the service of the Company for 35 years. During that time he never had a passenger injured on any of his trains, and was never suspended nor reprimanded nor subjected the Company to any cost whatsoever on account of accidents. The *John Bull* was on exhibition at the Centennial Exhibition in Philadelphia in 1876, and at that time the following description was published by the Pennsylvania Railroad Company, and had a wide circulation:

"The locomotive *John Bull* was built by Messrs. George

& Robert Stephenson, at Newcastle-upon-Tyne, England, for the Camden & Amboy Railroad & Transportation Company in the year 1831.

"It arrived in Philadelphia in August, 1831, and was transferred to Bordentown, N. J., on September 4, 1831.

ORIGINAL DIMENSIONS.

"Cylinders, 9 in. diameter by 20 in. stroke. One pair of driving-wheels, 4 ft. 6 in. diameter. One pair of wheels, 4 ft. 6 in. diameter, not coupled. Hubs of wheels were of cast iron, the spokes and rims of the wheels of wood. Tires of wrought iron, the weight about 10 tons.

"On arrival at Bordentown it was transferred from the sloop in which it had been brought from Philadelphia by means of wagons to the only piece of permanent track of the Camden & Amboy Railroad Company then completed, and about three-quarters of a mile in length, and about one mile distant from Bordentown. The machinery was then put together, and a tender constructed from a whiskey hogshead placed on a four-wheeled platform car, which had been used by the contractor in the construction of the road. The connection between the pump of the locomotive and the tank was made by means of a leather hose fitted up by a shoemaker in Bordentown. The locomotive was first put in steam, September 15, and several trial trips were made before the first public trial, on the 12th day of November, 1831, Isaac Dripps acting as engineer, Benjamin Higgins as fireman, and R. L. Stevens as general instructor and conductor. The members of the New Jersey Legislature and a number of other prominent persons were among the guests present.

"The *John Bull* remained at Bordentown until the year 1833, when the Camden & Amboy Railroad Company began running their cars by steam power, the road having been previously operated with horses. It was then placed on the road, doing the regular routine service, and continued in successful operation until 1866."

But little can be added to this description at the present time. The two cars were in marked contrast with those at present in use. The seats were a very old-fashioned pattern, and candor compels us to say were very uncomfortable. Evidently when they were made the anatomy of the human form had not been studied with as much care as it has been since by some of the designers of modern seats. The backs of the passengers were supported only at the shoulder blades. Their spinal columns received no attention in those early days of railroading.

The car had an old-fashioned arched roof, without ventilators or windows in it. The height of the floor to the eaves inside was 5 ft. 8 in.; the height of the center was 6 ft. 5 in. The ceiling was therefore destructive to plug hats worn by tall men. The windows consisted of two panes of glass each $8\frac{1}{4} \times 9\frac{1}{4}$ in. Between these was a wooden panel 17×21 in., which was arranged to lower like the window in an ordinary carriage. The windows themselves were fixed and could not be moved. Above the windows and panels and extending the whole length of the car were a series of pneumonic ventilators. Daylight could be seen through the crevices around almost any of them, and was very suggestive of uncomfortable drafts in cold weather. Small blue curtains were looped up over the windows, and resembled those used in children's play-houses.

The appliance for lighting the car consisted of a tallow candle in a sort of lantern on each end.

That which impressed the passengers on these cars was their extreme rigidity or the roughness of their movement on the track of the Pennsylvania Railroad. In recollecting the early days of traveling, one is apt to attribute the jolting to the rough roads of those early days, but even on the permanent way of the Pennsylvania Railroad these old cars were very uncomfortable.

One feature which attracted attention on the old engine was a sort of a buggy-top on the back end of the tender, which faces toward the rear end of the train. The history of this appliance is that in 1855 a very serious accident happened on the old Camden & Amboy Railroad at Burlington. A passenger train was there backing down over a road crossing, and ran into a carriage and pair of horses belonging to a Dr. Hanagan. The rear car was thrown off the track and the other cars crushed into one another, killing and wounding a large number of passengers. The buggy-top arrangement was then placed on all the tenders, and a lookout was stationed there whenever passenger trains were backed up.

Immense crowds were collected at all the stations between New York and Philadelphia, and the interesting feature was that the arrival of the train was greeted with a broad smile on the faces of each one of the spectators. The general verdict of all passengers on this excursion was that they preferred modern cars to those of the early days.

PATENALL'S IMPROVED SYKES' SYSTEM OF BLOCK SIGNALS.

By the Johnson Railroad Signal Company, Rahway, N. J.

I.

In describing any system of block signals it is always well to begin with a little preliminary explanation and description of the general principles which govern and require their use, as there are still many readers of an article like this who have very vague ideas about what is called the "block system."

In a general way it may be said that the block system is a consequence of what the natural philosophers used to call the "*impenetrability*" of matter, or "that property in virtue of which two portions of matter cannot at the same time occupy the same portion of space." When the momentum of a rapidly moving railroad train or vehicle impels it to occupy a space simultaneously with another train or vehicle, disastrous consequences are liable to result if they come into collision with each other. The block system has been devised to prevent such accidents, and to exclude more than one train or vehicle from given spaces on railroads at the same time.

The way in which this is done will be understood if we suppose we have a railroad tunnel with two tracks in it, on each of which trains run in only one direction. Obviously no collision can occur in it if, after a train has entered the tunnel on either track, a second train is not allowed to follow it on the same track until the first train has passed out of the tunnel at the opposite end. The same thing will be true if trains are controlled in the same way on any part or division of a double-track railroad.

In the block system this principle is applied to the whole length of the road by dividing it into districts or "block sections," as they are called, with signal stations between them. The sections may be of equal or unequal lengths, as may be convenient for working the traffic.

When a train, engine, or car is on either track in any one of these block sections, all other trains or vehicles are excluded from that track in that section. To illustrate this we will take as an example a portion of a double-track railroad, shown in fig. 1, on which trains run, we will say, "eastward" on one track, and "westward" on the other, as indicated by the darts. It should be understood that the engraving represents a ground plan of the tracks, and that the signaling apparatus, for convenience and clearness, is shown as though it was laid on the ground, and does not appear in its true position in relation to the tracks; neither is it drawn in its true proportions, some of the parts being relatively magnified in size for the purpose of representing them clearly.

Let it be supposed, now, that *R R* and *R' R'* represent two lines of rails of a double-track road, and that trains run, say, westward on one and eastward on the other, and that it is divided into block sections 1, 2, 3, and 4 of any convenient length, by signal stations, *A*, *B* and *C*, the stations being at the dividing points between the sections, and are connected together by telegraphic or electric communication.

Any form of signals might be used; but it will be supposed that they are of the semaphore type, and consist of a post, *M* (see station *A*, fig. 1), with a semaphore arm or blade, *S*, which is pivoted to the post at *h* so that it can be moved like the blade of a knife, and raised and lowered to and from the positions shown by full and dotted lines. When the semaphore *S* is lowered, or in the position shown by dotted lines S^2 at station *A*, it indicates that section 2 ahead of station *A* is "CLEAR" to station *B*, and when the semaphore is raised, as shown by full lines, it implies "DANGER," or that section 2 is occupied or "fouled," as it is sometimes called.

Usually there are two signals located close to the signal station, one referring to the one track and the other to the line on which trains run in the opposite direction. The signals *S*, *S'* and *S''* which are near to the stations are called "home signals." In the engraving, to avoid confusion and complication, only the signals referring to the west-bound track are shown, and will be described. Besides the home signals, other signals, *D*, *D'* and *D''*, shown by dotted lines in the engraving, are located at a distance of from 1,200 to 1,600 ft. from the home signals, according to the nature of the location and other circumstances. These distant signals will not for the present be referred to, but their purpose will be described later on.

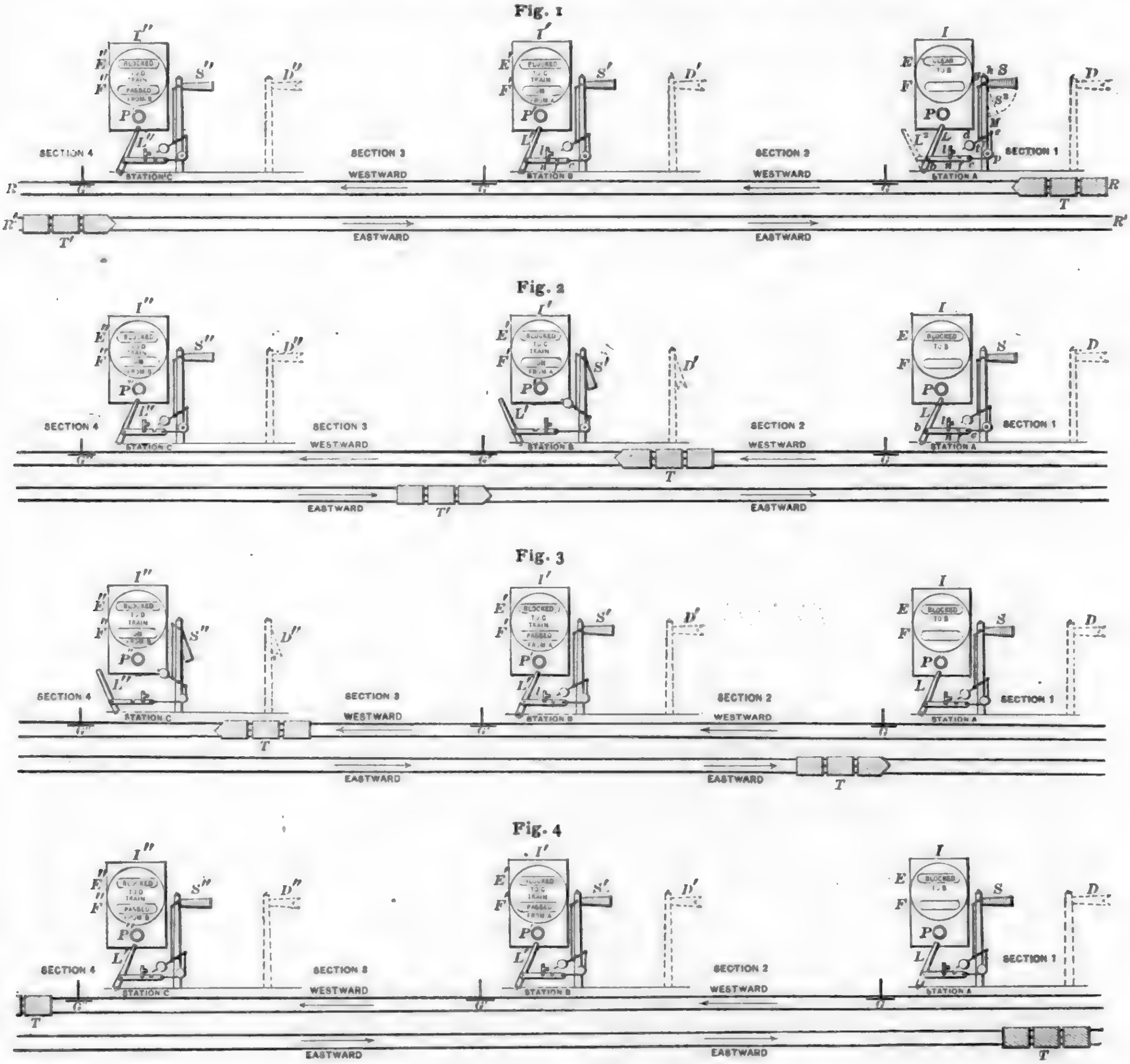
The semaphores are operated by a hand lever, *L* (see station *A*, fig. 1), which is connected to a bar, *b c*, and chain, *c p e*, which passes over a pulley, *p*, and is connected to another lever, *d e*, at *e*. The semaphore is pivoted or suspended on the post by a shaft at *h*, which has a short arm or crank, *h g*, attached to it. This is connected to the lever *d e* by a rod,

g t; d is a counterweight which is intended to throw the semaphore up, or to indicate "DANGER" in case the chain or wire *c* or other connection should be broken.

It is a maxim in law that every person must be assumed to be innocent until he has been proved to be guilty. In signaling, experience has shown that safety can be secured only by adopting the reverse of this maxim as a fundamental principle—that is, it must always be assumed that there is danger unless there is positive evidence that there is not, or, in other words, that the line or block section is "CLEAR." For this reason all signals are kept to indicate "DANGER" not only while the section to which they refer is occupied, but until it is required to indicate that the line is "CLEAR" to an approaching train.

Before describing the details of the mechanism which is used in connection with the system of block signals, which is the subject of these articles, an explanation will be given of its general principles and operation.

To do this it will be supposed that a train, *T*, is approaching station *A* in fig. 1 on the west-bound track, and that the signalman at station *A* has learned by telegraph from the signalman at *B* that the last west-bound train which left *A* has passed *B*, and therefore the track between *A* and *B* is unoccupied, or is "CLEAR." There can, therefore, be no danger that the train *T* will run into another one between *A* and *B*, as there is no train there to be run into. Consequently, on the approach of a west-bound train, the signalman at *A* would lower his home signal from the position shown in fig. 1 by full lines at *S* to that shown by dotted lines at S^2. It would then indicate to the engineer of train *T* that the line between *A* and the next station was "CLEAR," and he therefore could go ahead.



PATENALL'S IMPROVED SYKES' SYSTEM OF BLOCK SIGNALS.

As soon as the train passed station *A* then section 2 would be occupied, as shown in fig. 2, and therefore the signalman at *A* would raise his signal to danger and thus "block" section 2, and would not lower his signal again until he is notified by telegraph from *B* that the train *T* has passed *B*, thus leaving section 2 clear. If, when the train approached station *B*, as shown in fig. 2, section 3 was clear, then the signalman at

B would lower his home signal, *S'*, to the position shown which would indicate to the engineer that he may go ahead. As soon as the train passed station *B* and entered section 3 the signalman at *B* would raise his signal, as shown at *B*, fig. 3, and thus "block" the section in front of that station, and he would at the same time notify *A* that section 2 was again clear. When the train approaches station *C* the same operation would be repeated, and if the line was clear ahead of *C* the signalman at *C* would lower his signal, as shown in fig. 3, and would admit the train on section 4, and at the same time notify *B* that section 3 was clear, and raise his signal, as shown in fig. 4, to block section 4. The same method of operation is employed for trains running on the east-bound track, but, as before explained, separate signals, which are not shown in the engraving, are used for that track.

From this explanation it will be seen that if trains were run in perfect conformity with this system a rear-end collision would be impossible. Unfortunately both human nature and inanimate things seem to have an infinite capacity for falling into error and making mistakes, for neglect of duty, misconception of facts, and general wrong-headedness. A signalman may forget or not notice that a train has entered the section beyond him, and may admit a second one after it. He may go to sleep and not observe whether a train has passed his station or not, and may notify the signalman behind him that the section between them is clear when it is not. Blunders seem to be endowed with superhuman ingenuity, and only a history of railroad accidents would reveal their variety and causes. The occurrence of such accidents has led to the adoption of many ingenious appliances the purpose of which is to avert the consequences of human error in the operation of signals and running of trains. The system of operating signals, which is the subject of this article, has been devised for this purpose.

It has been explained that for the sake of security all signals are placed so as to indicate "DANGER" until safety is assured, and a clear signal is required for an advancing train. In order to make sure that signals will not be lowered unless the line is clear their levers, as, for example, *L*, shown at station *A*, fig. 1, is connected to a locking bar, *b c*, which has two notches, *f* and *n*. A latch, *l*, is arranged so that when the lever is in the position *L* shown by full lines, the latch will fall into the notch *n* and lock the lever and signal in that position, which indicates "DANGER." Another notch, *f*, is also provided; and when the lever is thrown over into the position L^2 and the signal is thus lowered, the latch *l* falls into *f* and locks the lever in that position.

Each station is also provided with two indicator cases, one for each track. In the engravings only one of these, *I*, is shown. These refer to the west-bound track only. It consists of a wooden case, *I*, which has two openings, *E* and *F*. The indicators *E*, *E'* and *E''* refer to the condition of the sections of track beyond or ahead of the stations, while *F*, *F'* and *F''* refer to that of the sections in the rear or behind the stations. The signal levers *L*, *L'* and *L''* are electrically connected with the indicators. When the signalman at any of the stations, as *A*, throws over the lever *L* to lower the semaphore and admit a train to section 2, that movement of the lever changes the indicator *E* at his station so that it will read "BLOCKED to *B*," showing that a train may now enter section 2. This indication is then no longer under *A's* control—that is, when once he has moved his lever to lower his signal which caused the indicator to read "BLOCKED to *B*," *A* cannot change that indication, but must depend upon *B* to do it for him, as will be explained further on.

Before *A* admits a train on section 2 it should be certain that there is no train on it or that it is "clear." If *A* depends upon information received by telegraph from *B*, there is always a chance for mistakes. They may misunderstand each other, or forget, go to sleep, or do many other things to which fallible and indolent human nature is prone. For this reason the mechanism of this system of signals is arranged so that when the signal at a station is raised to indicate "danger" it is locked in that position, and the signal man at that station cannot unlock it without the co-operation or consent of the signalman at the next station ahead of him. That is, when *A's* lever and signal are in the position shown by full lines in fig. 1, *A* cannot move them until *B* unlocks *A's* lever. *B* does this by means of an electrical connection between *A* and *B*, which is operated by what is called a "plunger," *P'*, which is a knob or button similar to an ordinary bell-pull, which is arranged in front of his indicator case, *I'*. The construction of this will also be explained hereafter.

Let it be supposed, again, that a train, *T*, is approaching station *A*, fig. 1, and the signal and lever at that station are in the position *S* and *L*, shown by full lines, and that the indicator *E* reads "BLOCKED to *B*." *A* may now ask *B* by telegraph or ringing an electric bell whether section 2 is clear, and if it is, to unlock his lever, or *B* may do so without receiving word from *A*, provided section 2 is clear. If it is, *B* does this by pressing in the knob of the plunger *P'*, which sends an electric current to *A*, which shifts *A's* indicator, *E*, to indicate "CLEAR to *B*," and unlocks his lever. When *B* releases the plunger and it springs back, his indicator, *F'*, shifts to "TRAIN ON from *A*," meaning that a train has been admitted to section 2 from *A*, and section 2 is therefore "blocked." When this operation has been performed the plunger is locked, so that it cannot be worked again to admit another train on section 2 until *B's* lever, *L*, has been pulled over again and returned.

Assuming now that *B* has unlocked *A's* lever and changed his indicator, *E*, to read "CLEAR to *B*," *A* would then throw his lever over and lower his signal to the position S^2 shown by dotted lines, which would indicate to the engineer that section 2 was clear and that he can go ahead. It may be repeated that, as this movement of the signal admits a train to section 2, it will simultaneously change the indicator *E* at station *A* to read "BLOCKED to *B*," showing that a train has, or is about to, enter on that section.

When the lever is thrown over into the position L^2 and the signal is lowered, the latch *l* drops into the notch *f* and locks the lever in that position. When the train passes the station it is important that it should get entirely clear of section 1, on which it has been approaching station *A*, before another train is admitted on that section, otherwise a following train might run into the first one before it was off of the section to which they were both admitted at the same time. It is partly to guard against such accidents that what are called automatic track treadles or track instruments *G* are provided. These consist of a device attached near to the inside of one of the rails, and is actuated by the wheels of trains as they pass over it. The details of the construction of such instruments will be described later. It will be sufficient to say now that it is electrically connected with the locking parts of the lever *L*, so that when the train passes over the instrument *G* the lever, which has been locked in the position L^2 when the signal was lowered, is then unlocked and can be returned home and the signal restored to the danger position, where it is again locked by the latch *l* dropping into the notch *n*.

It should be observed that *A's* lever and signal are now locked in the "DANGER" position, so that he cannot lower the latter to admit another train to section 2 until it is again unlocked, and *B's* plunger is also locked, so that he cannot release *A's* lever, and therefore it is impossible to admit another train on section 2 until *B's* plunger is unlocked.

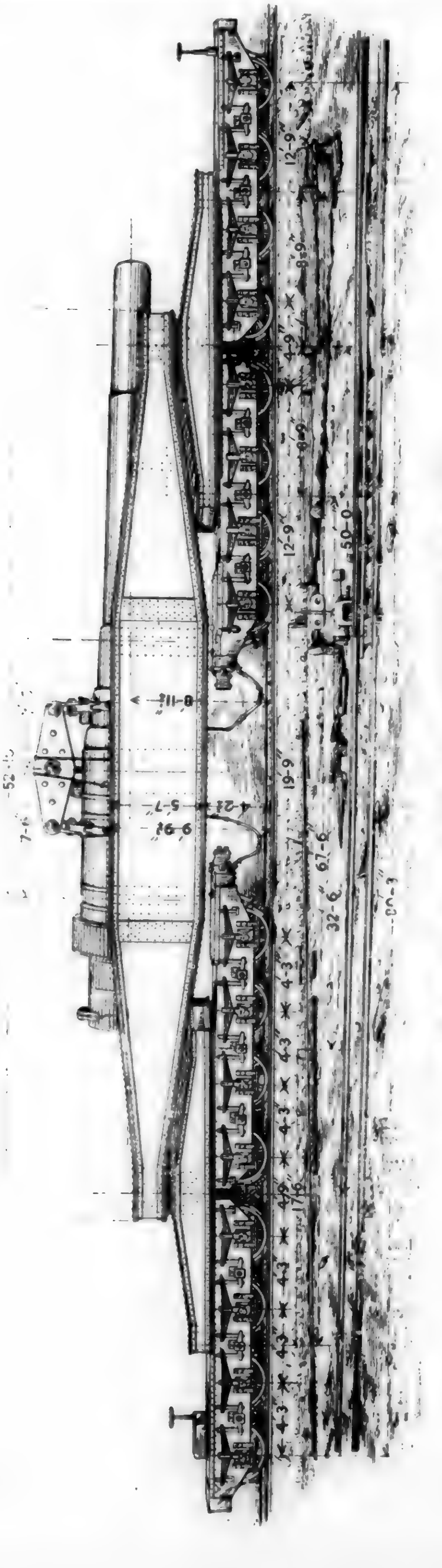
As the train approaches *B*, if section 3 is clear and *C* has unlocked *B's* lever, his indicator, *E'*, would read, "CLEAR to *C*," and *B* can then throw his lever over, and we will have the condition of things shown in fig. 2—that is, *B* has lowered his signal *S'* to admit the train to section 3. In doing this the movement of his lever has changed his indicator, *E'*, to read "BLOCKED to *C*," showing that a train has or is about to enter section 3, and *B's* signal is lowered and his lever *L'* is locked in the position in which it is shown in fig. 2. When the train passes over the track instrument *G'* at station *B* the action of the wheels unlocks *B's* lever, and it may then be returned home and his signal lowered. This movement of his lever releases his plunger, *P*, and enables him to unlock *A's* lever and change his indicator, *E*, to read "CLEAR to *B*," and we then would have the condition shown in fig. 3. *B's* lever then remains locked until the train has passed *C's* treadle, and *C* has pressed in his plunger, *P''*. Should another train approach *B* from *A* before *C* has thus unlocked *B's* lever, *B* cannot lower his semaphore even should he attempt to do so, and the train must stop until *B's* lever is unlocked by *C*.

A may now ask *B* by telegraph or by ringing an electric bell to relock his lever again, and *B* can do this by pressing in the plunger *P'*, which, as explained, sends an electric current to *A*, unlocks *A's* lever, shifts *A's* indicator, *E*, to "CLEAR to *B*." When *B* releases the plunger and it springs back, his indicator, *F*, shifts to "TRAIN ON from *A*," which means that *A* has or may admit another train to section 2.

The plunger is then locked automatically again, so that it cannot be worked until *B's* lever, *L'*, has been pulled over and another train has passed over his track instrument, *G'*, and the lever returned. The lever then remains locked until the train on section 3 has passed *C's* track instrument, *G''*, and unlocked *C's* lever, and it has been returned home and released his plunger. He will then be enabled to plunge and unlock *B's* lever.

It will thus be seen that not only is the *concurrence* of two signalmen required before a clear signal can be given, but their co-operation is not possible until *after* the train has passed over the track instrument of the station in advance.

During the further movement of the train the action of the signals at the succeeding stations is exactly similar to that



CAR OF 285,000 LBS. CAPACITY FOR THE TRANSPORTATION OF HEAVY GUNS.

which has been explained. When it approaches station *C*, as shown in fig. 3, if section 4 is clear, and the signalman beyond has released *C's* signal, he lowers it into the position in which it is shown. This movement changes *C's* indicator, *E''*, from "CLEAR" to "BLOCKED," to show that a train has been admitted to section 3. When the train has passed over the track instrument *G''* it unlocks *C's* lever, *L''*, and it is returned home, as shown in fig. 4. At the same time the indicator *E''* at station *C* has been changed from "CLEAR" to "BLOCKED," and *F''* from "Train ON from *B*'' to "Train PASSED from *B*." The lever *L'* at station *B* may now be unlocked by *C* and the indicator *E'* at *B* changed from "BLOCKED" to "CLEAR" on the approach of another train.

The movement and control of trains and the action of the signals on the east-bound track is exactly similar to that which has been described, it being understood that the whole apparatus is duplicated—that is, that there are separate levers, signals, indicators, and treadles for each track.

The object of the distant signals *D*, *D'* and *D''* is to give the engineer warning of danger at a sufficient distance from the stations, so that he can control his train before reaching the home signal and the section which is not clear. The distant signals are operated by separate levers, not shown in the engravings, which are arranged in such a way that to indicate danger the movement of the distant signal always precedes that of the home signal—that is, if a section is blocked, the distant signal is raised first to protect the rear of the train. To admit a train they are moved in the reverse order—that is, the home signal is lowered first and the distant signal afterward.

From what has been said it will be seen, then, that with this system of signals an engineer, when he approaches a station, should be controlled first by the distant signal and next by the home signal. A signalman at any station—as *A*, for example—cannot lower his signals to indicate that the line is clear until the signalman at *B*, next in advance of him, has notified *A* that the section between them is clear, and has unlocked *A's* signal lever. If *A* has admitted a train on the section, *B* cannot give a signal to *A* that the line is clear and unlock his lever until the train on the section has passed *B's* station and operated his track treadle. After this operation has been performed, *and not before*, *B* can notify *A* that the section is clear, and can then unlock *A's* lever. *A* can *then* lower his signals, but not until *after* these operations have been performed.

In other words, the engineer is governed by the signals, the signalman is controlled by the man at the next station ahead of him, and he is governed by the action of the train on his track treadle. This, it is thought, gives the highest degree of security which has yet been attained by any system of signaling.

In one or more other articles the mechanism employed with this system of signaling will be described.

CAR FOR CARRYING HEAVY GUNS.

WE illustrate the car which has recently been built by the Pennsylvania Railroad Company for carrying the heavy guns intended for the Chicago Exposition. It was built more particularly for the big gun sent over by Krupp. It is shown with this gun in position, just as it was loaded from the steamer at the Sparrow Point Iron Works, at Baltimore, Md. It has a capacity of 285,000 lbs., and is built entirely of boiler steel; the center plates and center bearings being steel castings. It consists, as may be seen by referring to the engraving, of a major bridge, two minor bridges, and four eight-wheel cars. The gun rests in the major bridge on two supports designed to closely fit its perimeter. In addition to these two supports, to avoid any vibration while in transport, the muzzle is secured by wedge shaped oak blocks set in cast-iron shoes and drawn up to the muzzle by means of right and left-hand screws. The major bridge is 50 ft. from center to center of supports, and rests directly on the side bearings, while, on the other hand, the minor bridges are supported by their respective center plates.

The cars have been designed so as to combine strength with flexibility, and are equipped with Janney couplers and draft rigging specially constructed for strength.

The journals are 4½ in. × 9 in.; 37½-in. wheels with wrought-iron centers and steel tires are used.

Each car has a 14-in. Westinghouse air-brake cylinder with brake on all wheels, and National hollow brake beams with Christie brake heads and shoes.

The load on cars is thoroughly equalized by 32 elliptic springs of 36-in. span, each spring having 18 leaves 3½ in. wide and ⅜ in. thick.

The extreme length of car is 90 ft. 9 in.; extreme width, 9 ft. 10 in.; extreme height to top of bridge, 9 ft. 9¾ in.

AMERICAN AND ENGLISH LOCOMOTIVES.

(*Continued from page 168.*)

In this number of the American Engineer we give engravings of the cylinders of the American and of the English locomotives which have formed the subject of this series of articles. The following are the specifications of the cylinders of the American engine :

CYLINDERS.

Of close-grained hard charcoal iron. Cast with half saddle attached, the right and left cylinders from the same pattern and interchangeable. Fitted together in a substantial manner, and securely bolted and keyed to frame. Valve face and steam-chest seat raised above face of cylinder to allow for wear. Cylinders oiled from Nathan No. 9 double sight feed lubricator placed in cab, with copper pipe under boiler lagging to steam-chest.

PISTONS.

Made with removable follower, and fitted with approved cast-iron steam packing. Piston-rods of hammered iron.

SPECIFICATIONS OF CYLINDERS OF ENGLISH EXPRESS LOCOMOTIVE.

CYLINDERS.

The cylinders are to be 19 in. in diameter when finished, with a stroke of 26 in. The steam ports are to be 16 in. long and 1⅝ in. wide. The exhaust port is to be 16 in. long and 3 in. wide. The bars are to be 1¼ in. wide. The cylinders are to be made of best close-grained, hard, strong cast iron ; they must be as hard as they can be made, to allow of their being properly fitted and finished, and must be perfectly free from honeycomb or any other defect of material or workmanship ; they must be truly bored out, the front end being bell mouthed. All the joints, covers and surfaces are to be planed or turned and scraped to a true surface, so that a perfect joint can be obtained. All studs are to be tightly screwed. The cylinders are to be made with loose covers at both ends, provision being made on the back cover for carrying the slide bar. They are to be set in a horizontal line, placed at a distance apart of 6 ft. 2¼ in. from center to center, with steam-chest on side, as shown on drawing. The holes in the frames and flanges of the cylinders are to be carefully rimmered. When the cylinders are correctly set to their places they are to be firmly secured to the frames by turned bolts 1¼ in. in diameter driven home to a tight fit. The cylinders are to be covered with lagging and clothing plates 14 Standard W. G. thick. The front and back cylinder covers are to be protected by clothing plates secured as shown. The cylinders before being fixed in position to be tested in the presence of the Railway Company's Locomotive Superintendent or his Inspector by hydraulic pressure to 200 lbs. per square inch. All joints must be perfectly tight under this pressure ; the front and back cylinder covers and cylinders generally to be exactly to the drawing.

PISTON AND PISTON-RODS.

The pistons are to be made of cast steel, free from honeycomb or any other defects, to the form and dimensions shown on drawing, and are to be fitted accurately to the cone of the rods, and secured thereon by gun-metal nuts formed with collars and taper steel pins through the nut. The piston head is to be an easy fit in the cylinder ; the packing rings are to be three in number, of cast iron ⅜ in. wide, ½ in. thick, and turned all over. The rings are to be turned larger than the diameter of the cylinders, then to be cut and sprung in to fit the bore in the cylinders, and are to be prevented from turning round in the piston by dowel pins fixed in the position shown. When finished, the whole must be an easy and accurate fit, so that the finished rod and piston can be moved readily backward and forward in the cylinder. The piston-rods are arranged to work through both front and hind cylinder covers, and to be 3⅜ in. diameter at back end and 2¼ in. at front end, and are to be forged from the very best cast steel of approved make, with a breaking strength of 30 tons per square inch ; they are to be truly fitted to the heads, and are to be tapered where they enter the cross-head, and to which they are to be secured by cotters of mild Swedish steel. Full particulars of the various dimensions and tapers are to be obtained by reference to the full size drawings.

METALLIC PACKING.

Both piston-rods to be fitted with the United States Metallic Packing Company's packing, which is to be obtained from that company. The hind cylinder cover is to be arranged, as shown on the detail drawing, to suit this packing, and the front cylinder cover to have a stuffing-box, which is also fully shown on the drawing.

SLIDE VALVE.

The slide valve is to be of the best Stone's bronze, to be made exactly as shown on the drawing, and with recesses in its working face.

VALVE SPINDLES.

The valve spindles and buckles are to be of best Yorkshire iron and of the dimensions shown on drawing. The spindles are to be guided by gun-metal glands and bushes through the steam-chest ; the valve spindle is to be tapered where it enters the valve rod, and is to be secured by a cotter of mild Swedish steel.

Whatever the opinions of our readers may be of the relative merits of the construction of the two engines referred to herein, they will agree with us probably in thinking that the specifications of the English locomotive are a great deal fuller, more explicit and complete than those of its American contemporary.

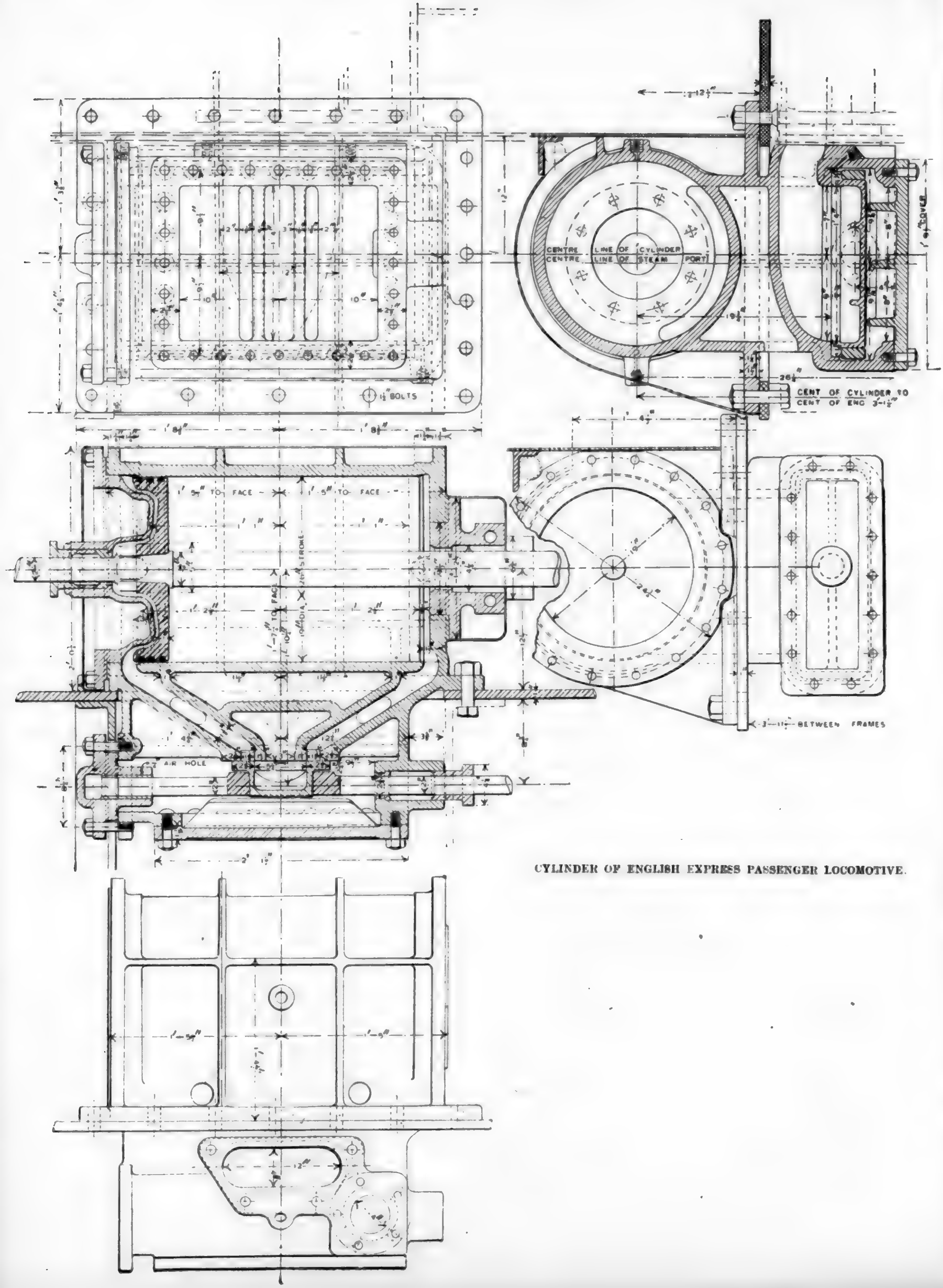
Attention has already been called, in our January number, to the difference in the cylinder capacity of the two engines. It was shown there that taking the size of the driving-wheels, the weight on them, and the boiler pressure into account, the relative cylinder capacity of the American engine, if compared with that of the English machine, is as 460.65 to 590.4—that is, the English cylinders, in proportion to the size of wheel, adhesive weight, and steam pressure, have about 28 per cent. more capacity than those of the New York Central engine. Taking the average effective pressure in the cylinders, at very slow speeds, at 90 per cent. of the boiler pressure, the pistons of the New York Central engine would then exert a tractive force of 16,614 lbs., which is a little over 20 per cent. of the weight on the driving-wheels. The pistons of the London & Southwestern engine, calculated on the same basis, would exert 17,394 lbs., which would be equal to a little over 25 per cent. of the adhesive weight. The interesting question then comes up, Which engine has the best proportioned cylinders? If the cylinders of a locomotive are too large, it then becomes what locomotive runners call "slippery"—that is, the wheels slip before or as soon as full boiler pressure is admitted to them, even when cutting off steam at considerably less than full stroke. On the other hand, if the cylinders are too small, it is necessary to admit steam to them during the larger proportion of the stroke, and there is thus a loss of economy due to the fact that the steam is not worked with a sufficient amount of expansion. There can be no doubt that the maximum load which a locomotive will pull is diminished if it is over-cylindered, owing to the fact that the full steam pressure cannot be exerted on the pistons for a sufficiently long time to start or pull the load without slipping the wheels.

The following figures relating to the adhesion of locomotive wheels on the rails are easily remembered :

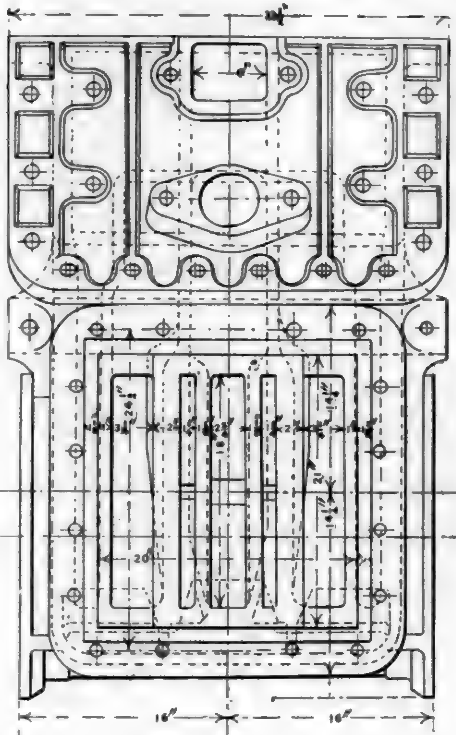
On dry sanded rails adhesion	= ⅓ the insistent weight.
" " rails not sanded adhesion	= ¼ " " "
" rails in ordinary condition adhesion	= ⅕ " " "
" rails in bad condition adhesion	= ⅛ " " "

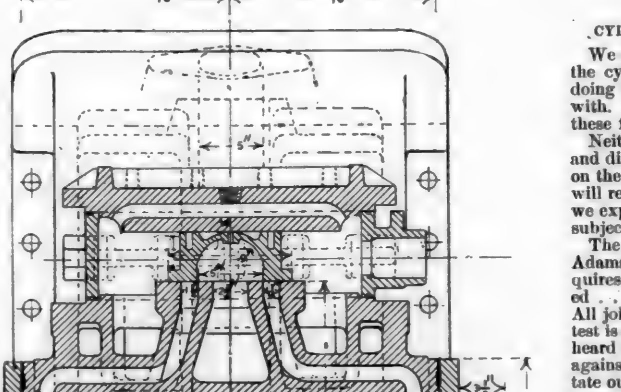
From these figures it would appear that Mr. Buchanan's engine would not be able to slip its wheels if their adhesion exceeded ⅕ the weight on the rails below them, and Mr. Adams's engine could not do so if the adhesion was over ¼. It must be remembered, however, that the tractive power of a locomotive, as calculated by the ordinary rules, is the *average* power exerted during one revolution of the wheels. The actual rotative force exerted by the steam at the circumference of the wheels varies through the whole revolution. At one point the force exerted is nearly or quite 20 per cent. greater than the *average*. This occurs when both cranks are in front of the axles and stand at angles of 45° with horizontal and perpendicular lines. In working with its maximum steam pressure, Mr. Adams's engine therefore would exert a tractive force equal to 30 per cent. of the adhesive weight at this point in each revolution, and Mr. Buchanan's would exert 24 per cent. If the wheels begin to slip at this or any other point in their revolution, they are liable to continue to do so during the rest of it, even if the tractive force or rotative effect is less during the remainder than it was at the point where the slipping commenced.

The inference may, therefore, be drawn from these facts and inferences that Mr. Adams's engine would be "slippery" when working up to its maximum capacity unless the rails were dry and sanded, or in the best possible condition to give a high coefficient of adhesion. On the other hand, Mr. Buchanan's engine would seem to be slightly deficient in cylinder capacity when the rails are in *good* condition, and still more so if they are dry and sanded. We are inclined to believe that both of

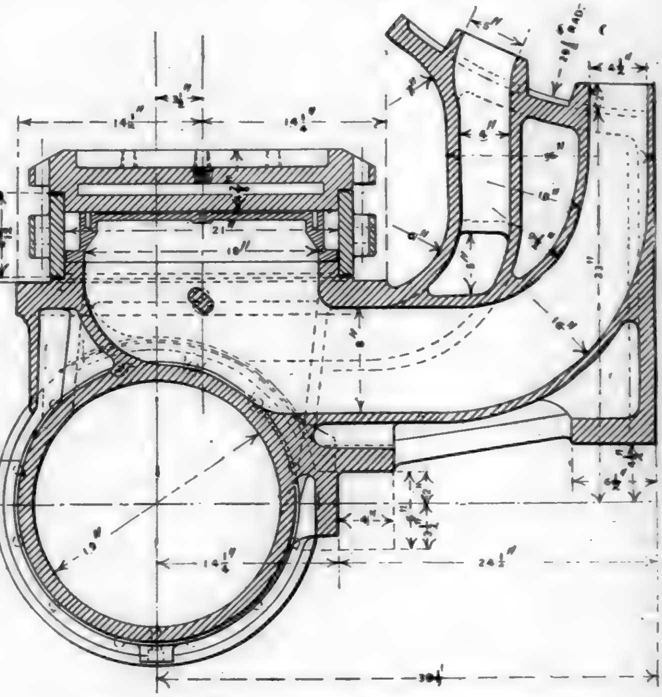


CYLINDER OF ENGLISH EXPRESS PASSENGER LOCOMOTIVE.





the engines would be improved if Messrs. Buchanan and Adams were to swap cylinders, so that the heavier engine would have 26 in. stroke and the lighter one 24 in.



CYLINDER OF AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

We will not refer in this article to the method of fastening the cylinders to the frames and smoke-box, as the method of doing this is not shown very clearly in the engravings herewith. In other illustrations which it is intended to publish these features will be clearly represented.

Neither will we have anything to say here of the advantages and disadvantages of placing the steam chests and slide valves on the sides of the cylinders and between the frames, as we will reserve comment on this feature until next month, when we expect to give illustrations of the valve gear, and the whole subject will then be discussed in one article.

The attention of our readers is called to that feature in Mr. Adams's specifications of the cylinders of his engine which requires that "before being fixed in position they are to be tested . . . by hydraulic pressure to 200 lbs. per square inch. All joints must be perfectly tight under this pressure." This test is never applied in this country, or if it is, we have never heard of it. It seems to be an excellent precaution to guard against defective castings and workmanship. We might imitate our English brethren in this particular to our own advantage. It seems, though, that the difference of only 25 lbs. between the test pressure and the boiler pressure is hardly enough for a "factor of safety."

A comparison of tests of the cast iron used in the cylinders made here and made there would be interesting, to show the difference in the quality of the material used here and in England.

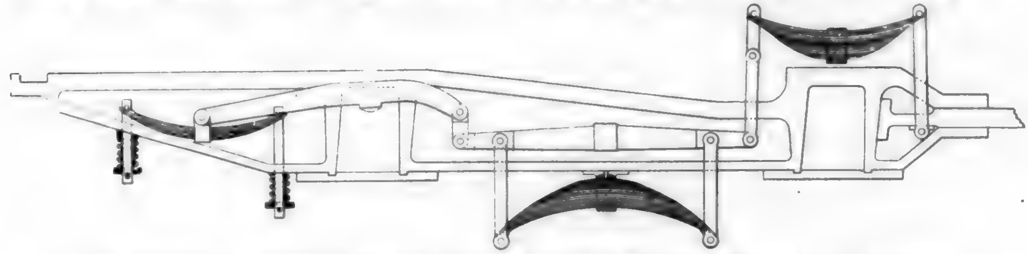
The piston heads of the English engine, it will be seen from the specifications, are made of cast steel. Those in the American engine are cast iron. The former is also a simpler and lighter structure than the latter, but it makes a somewhat complicated-shaped cylinder head necessary to conform to its contour. Probably most American master mechanics would be in doubt about cast-steel piston heads wearing satisfactorily if they came in contact with the inside surface of the cylinders. Is it this apprehension that has led to the extension of the piston-rods of the English engine through the front cylinder-head? Pistons on our engines are run with entire satisfaction without the extension of their rods. Now, if American cast-iron pistons will run satisfactorily without the extended piston-rods, packing, etc., they are cheaper and simpler—that is, the cost of our

more complicated pistons made of cast iron will be less than that of simpler pistons made of cast steel, plus the extended piston-rods, packing, etc. It will be noticed that in the specifications it is required that these cast-steel pistons and rods "when finished, the whole must be an easy and accurate fit, so that the finished rod and piston can be moved readily backward and forward in the cylinder." If this means that they are to be moved by hand, it is a requirement that we are inclined to think most American builders would not readily conform to.

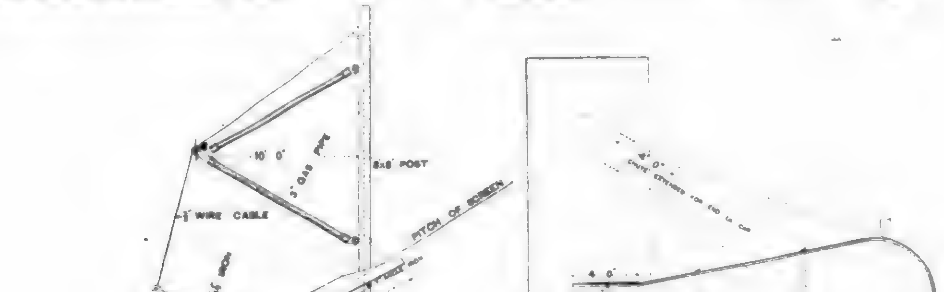
The American piston-rods are specified to be of "hammered iron;" those of the English engine "are to be forged from the very best cast steel of approved make." Steel piston-rods have been extensively used here, but appear to have lost ground of late; and iron is now preferred by many locomotive superintendents.

The piston-rod packing is "United States metallic" for both engines, which leaves no room for discussion. In our next article we expect to give engravings of the valve gear of the two engines.

It may be added here that since our last issue we have learned that the weight of the cast-iron driving-wheel centers of the New York Central engine, including the counterweights, is for the main or front wheels, 3,254 lbs., and for the rear or trailing wheels, 3,147 lbs. This is the weight of castings rough—that is, before they are turned or bored.



ARRANGEMENT OF EQUALIZERS ON FOUR-COUPLED ENGINES, DELAWARE & HUDSON CANAL COMPANY.



SWINGING COAL SHUTE AT QUAKER STREET, ON DELAWARE & HUDSON CANAL COMPANY RAILROAD.

SOME EXTREME SPEEDS.

Mr. James Jackson has taken the pains to gather together in a tabulated form a large number of speeds, from the growth of finger nails to the velocity of electricity, taking up that of winds, projectiles, stars, etc. He has drawn up a list of about 300 velocities in this manner, taken from numerous authors, which we cannot produce entire, but limit ourselves to some of the more interesting figures given in his table.

	Ft. per second.
Growth of finger nails	.000,000,006,56
Growth of bamboo	.000,090,998
Flow of blood in the capillary passages of the human system	.000,024,6
Fall of the earth toward the sun	.009,84
Reading of current text	.124,64
A man climbing a staircase	.492
Progress of the eel	.639,2
Combustion of powder in a breech of a cannon of large calibre	1.049,6
Flow of blood in the aorta of a dog	1.312
Man walking 2¼ miles an hour	3.640,8
Man swimming 300 feet in 65 seconds	4.61
Man walking 3¾ miles an hour	5.444,8
Flow of a rapid river	13.12
Vessel at nine knots an hour	15.186,4
Maximum of the inaugural train of the Manchester and Liverpool R. R., on September 15, 1830	17.580,8
A racing boat, Cambridge and Oxford, 1873	23.88
Ordinary wind	16 40 to 19.68
A fresh breeze	21.943,2
A wave 100 feet high by 900 feet long	22.369,6
Ordinary flight of a fly	24.998,6
A blow of the fist	27.88
Skater upon roller skates	30.996
Fall of a body toward the surface of the earth at the end of one second	32.176,8
A stiff breeze	32.8
Drops of rain	36.08
Skater upon ice	39.819,2
Velocipede	40.00
Flight of a pelican	21.976 to 51.332
A railroad train at 37¼ miles per hour	54.677,6
Flight of the quail	56.384
Self-propelling torpedo	59.04
A horse on a gallop	60.368,8
A tempest	82 to 98.40
Fall of a body toward the surface of the earth after a fall of 328 feet	145.471,2

A storm that will uproot trees	147.60
Great waves of the ocean	150.312,4
Flight of the swallow	219.76
Transmission of sensation in the nervous system of a man	432 96
Initial velocity of a ball at the muzzle of a gun	675.68
Fall of a body at the surface of the sun after a fall of one second	884.845,6
Sound in quiet, dry air	1,086.008
Initial velocity of a ball at the muzzle of a field gun	2,083 6
Revolution of the moon about the earth	3,181.6
Initial velocity of a cannon ball	3,322.64
Sound in bronze and in oak wood	11,899.84
Aerolite falling 14th of May, 1864, at Tarn-et-Garonne	65,600.
Revolution of the earth about the sun	96,822.32
Halley's comet at perihelion	1,289,040.
Revolution of the visible satellite of Sirius	4,031,100.
Electricity on the submarine cable	3,120,000.
Electricity on telegraph wire	118,080,000.
Lightning in a solar spot	656,000,000.
Light in water	738,000,000.
Light in air	984,000,000.
Electric current carrying the discharge of a Leyden jar over a copper wire $\frac{1}{16}$ of an inch in diameter	1,520,280,000.

—*Revue Scientifique.*

CYLINDER SIZES OF LAKE ENGINES.

Below is given the sizes of a number of lake engines and the boats in which they are placed. In addition to the direct information given, the list shows the lake practice of proportioning cylinders. The engines are all triple expansion, except where otherwise designated.

28, 42½ and 72 in. × 54 in. stroke—*Owego* and *Chemung.*

26, 42 and 70 in. × 42 in. stroke—*Christopher Columbus.*

25, 36, 51½ and 74 in. × 42 in. stroke, quadruple—two in each of the twin-screw Northern steamers.

42 and 66 in. × 132 in. stroke, compound vertical beam—*City of Alpena* and *City of Mackinac.*

26, 42 and 66 in. × 72 in. stroke, inclined triple expansion for paddle wheels—*City of Toledo.*

24, 39 and 63 in. × 48 in. stroke—*Maritana* and *Mariposa.*

24, 38 and 61 in. × 42 in. stroke—six Northern steamers, six Minnesota steamers, six Menominee steamers, five Lehigh steamers, two Mutual steamers, *Pontiac, Aurora* and *Bradley.*

23, 36 and 62 in. × 48 in. stroke—*Hudson.*

23, 37 and 62 in. × 44 in. stroke—*Merida* and *W. H. Gilbert.*

23, 38 and 62 in. × 36 in. stroke—*Manitou.*

23, 37½ and 63 in. × 44 in. stroke—*Centurion.*

23, 37 and 62 in. × 42 in. stroke—*Emily P. Weed* and *C. B. Lockwood.*

22, 35 and 56 in. × 44 in. stroke—*E. C. Pope.*

21, 33½ and 57 in. × 42 in. stroke—*Fred Pabst.*

21, 33 and 56 in. × 42 in. stroke—*Volunteer.*

20¼, 32 and 54 in. × 42 in. stroke—*Roumania.*

20, 32 and 52 in × 42 in. stroke—*Olympia, Samuel Mitchell* and *Schuylkill.*

20, 32 and 52 in × 36 in. stroke—two in twin-screw steamer *Virginia.*

20, 32 and 54 in. × 42 in. stroke—*Alexander Nimick* and *Helena.*

20, 33 and 54 in. × 42 in. stroke—*Pioneer.*

20, 32 and 52 in. × 40 in. stroke—*Sitka* and *Gogebic.*

20, 33 and 54 in. × 40 in. stroke—*Yumna.*

20, 31 and 52 in. × 40 in. stroke—*Neshoto, J. C. Lockwood* and *Frontenac.*

19, 32 and 52 in. × 45 in. stroke—*Brazil.*

19, 30 and 52 in. × 40 in. stroke—*George W. Roby, Tom Adams, Philip Minch, Lackawanna* and *Scranton.*

18, 30 and 48 in. × 40 in. stroke—*Gilchrist.*

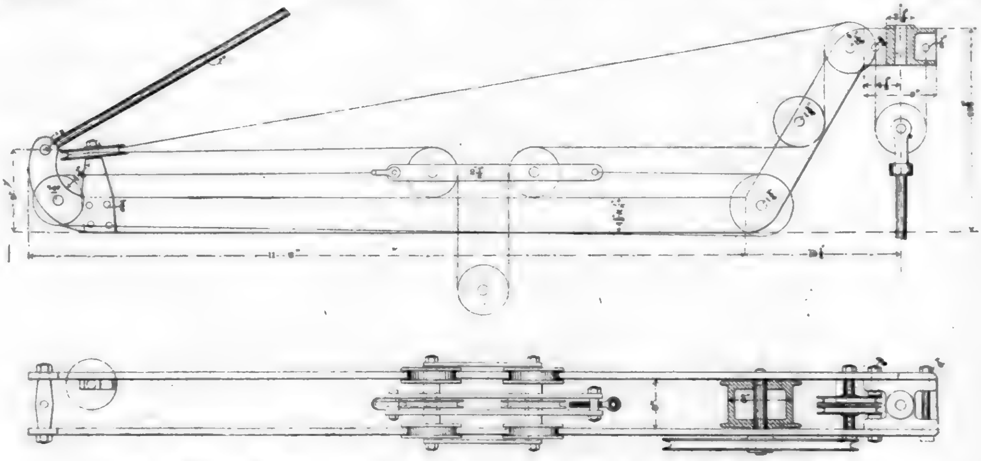
17, 29 and 47 in. × 36 in. stroke—*La Salle, Joliet, Wawatam, Griffin, Wade* and *Hesper.*

17, 28 and 46 in. × 30 in. stroke—*Rosedale.*

15¼, 26 and 42 in. × 22 in. stroke—*Wadena.*

15, 25 and 42 in. × 30 in. stroke—*Cadillac.*

—*Marine Review.*

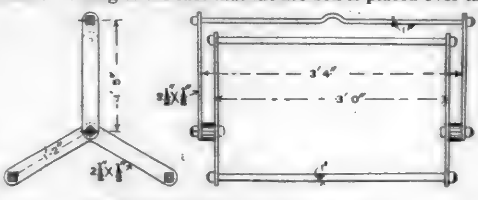


OIL-HOUSE CRANE, DELAWARE & HUDSON CANAL COMPANY'S SHOPS, GREEN ISLAND, N. Y.

SPECIAL TOOLS IN USE ON THE DELAWARE & HUDSON CANAL COMPANY'S RAILROAD.

In our last issue we illustrated a number of special tools that have been designed and constructed in the shops of the Delaware & Hudson Canal Company, and we continue the subject with illustrations of a few more, regretting, however, that it is impossible, from lack of space, to present as many as we would like.

Before taking up the tools that belong especially to the road, we call attention to an arrangement of equalizers between the driving-wheels of four-coupled engines which is extensively used, but which we believe belongs to the Dickson Locomotive Works. Owing to the fact that the fire-box is placed over the frames and that the latter have been cut away, it is necessary to place the springs below. A spring is therefore placed over the front axle-box in the ordinary way, and this spring is attached to the frame and the regular equalizer by hangers of the usual construction. The main equalizer, however, is floating—that is, it has no connection with the frame direct, but instead is coupled to a heavy spring having 17 leaves, which is placed below the lower bar of the frame and against which it bears. On the rear driving-box there is a lever with unequal legs, the longer one of which is coupled to a light spring, which is, in turn, attached to the frame through coil springs. The system produces a very easy riding engine. The use of the auxiliary coil springs under the frame at the end has



BARREL RACK FOR OIL-HOUSE CRANE.

come to be recognized as the proper thing where easy riding is aimed at, and the addition of the equalizing spring simply adds to what has already been done. The equalizing lever serves the purpose of holding the spring in position and protects it from all surging strains which it would receive were it not so protected.

SWINGING COALING SHUTE.

At Quaker Street there is a very convenient swinging coaling shute for loading gondola cars. The general construction will be easily understood from the engravings. The inclined screen delivers the coal upon a shute that is 7 ft. 4 in. wide at the upper end, but which narrows down to 24 in. where it delivers the coal to the cars. This shute has a movable slide at the narrow end, by means of which it can be extended 36 in. Thus, when a car is hauled into position, the coal can be turned on and the shute swung from one end to the other and the car loaded without the necessity of moving it with the engine. The shute is capable of loading a gondola car of 25 tons capacity in four minutes.

CRANE FOR OIL HOUSE.

The oil room at Green Island is the model of neatness and convenience. Along one side there are ranged five large tanks for oil having the following capacities: Tank for valve oil, 34 bbls.; engine oil, 35 bbls.; car oil, 34 bbls.; kerosene, 35 bbls.; and signal oil, 15 bbls. The tanks are square, and the room is heated by the McElroy commingler system; but when steam is not available, it is heated by a Baker heater. The oil is delivered to the room in the barrels, which are hoisted to the top of the tanks by the crane illustrated, and the oil runs directly into them. The crane consists of two bars of wrought iron 4½ in. × ½ in. bent to the form shown. They are pivoted to a center bolted to the wall and stayed by a ⅞-in. rod. A traveler which may be racked in and out completes the crane rigging.

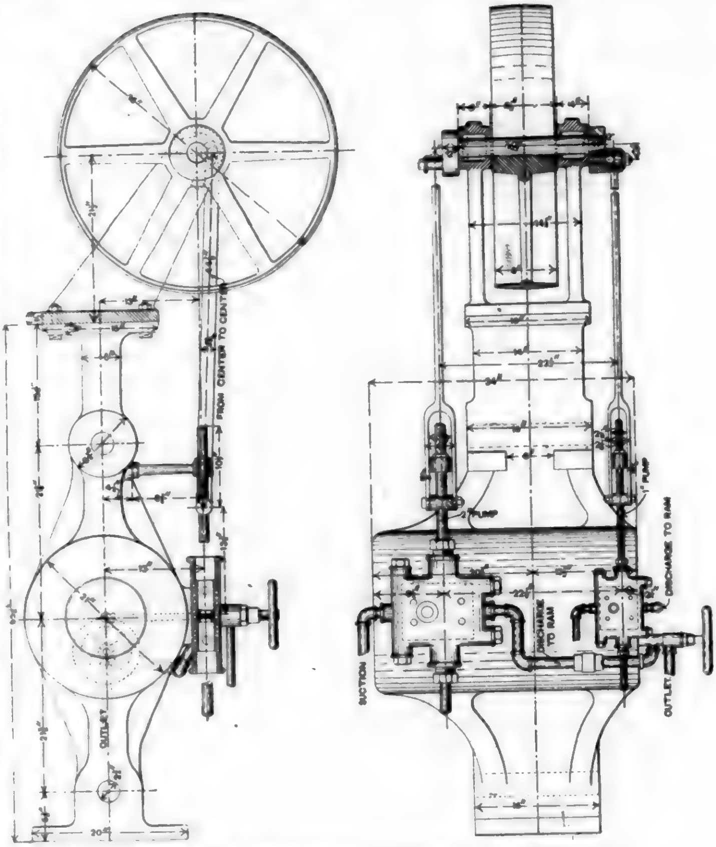
The hoisting is done with a hydraulic cylinder, like all the other work of the same kind in these shops. The engraving shows the upper end of the piston rod. The cylinder is vertical, and has a stroke of 6 ft. with a diameter of 7 in., and works under a pressure of 75 lbs. per square inch.

The barrel rack is shown, and is a simple home-made affair. One of the rods at the bottom is removable. The rack is lowered to the floor, the movable rod taken out, and the barrel rolled into the rack, after which the rod is replaced and the barrel is held firmly in position.

HYDRAULIC WHEEL PRESS.

In the Green Island shops there is a wheel press that Mr. Cory, the Master Mechanic, says is an example of an evolution. It was originally a screw press, but has been changed from time to time until now it is in the form shown by our engravings. The side and end elevations give a clear idea of the construction of the head and cylinder. The tie rods are 2¾ in. in diameter, and the two pumps have plungers of different diameters, so that the speed can be varied to suit the work in hand. It is possible, however, to run both pumps at a pressure of 40 tons, so that for the ordinary work of pressing on car wheels the full speed can be utilized. It is a big story to tell, but this press has put 52 pairs of wheels on their axles in 65 minutes. It will be seen, from the engraving of the vertical section of the pump, that the plunger is arranged so that it is double-acting, and there is a continuous flow of liquid from the pump to the ram from both pumps. The substantial construction of the machine and the record that it has made certainly is sufficient evidence of its value.

We will continue the illustration of these special tools in our next issue.



HYDRAULIC PRESS, DELAWARE & HUDSON CANAL COMPANY.

METHODS OF TIN MINING IN THE MALAY PENINSULA.

In a recent report, the United States Consul at Singapore gives an interesting account of the methods of mining pursued by the Malays and Chinese in the extraction of tin from the tin deposits of the Malay Peninsula. It appears from the report that more than one-half the world's tin is mined in the Straits Settlements, the output for the year 1891 being 57,551 tons, against 36,061 tons for the Straits Settlements. If to this 36,061 be added the 12,106 tons, the output of the Netherlands, India, whose tin-bearing islands are within a few hours' steam of Singapore, it leaves but 9,384 tons for the rest of the world.

Up to the introduction of modern tin mining and smelting machinery, in 1889, the tin was worked for a century in a most primitive fashion by the Malays. They simply dug down at the base of a hill, took up the clay which contained the *biji timah* (small nodules), and carefully washed it in running water. When dry it was melted in a furnace built of clay between two layers of charcoal, the fire being forced into a glow by means of bamboo bellows. When the metal became molten it trickled through a hole in the bottom of the furnace into a vessel, from which it was ladled into molds, forming slabs weighing about two catties (2⅔ lbs.). A rajah or chief's wealth was reckoned in bars or slabs of tin.

The primitive tin mining of the Malays gave place to the more energetic and thrifty mining of the Chinese, who brought with them better tools and better business methods. The Chinese monopolized the entire field until the formation of the Jelebu Company in 1889, with which the Chinaman can still compete. The Chinaman's manner of working is simple, though thorough. As the float tin lies at a distance of from 20 ft. to 50 ft. from the surface, gradually diminishing toward the hill sides, where it is not more than 6 ft., the jungle is

cleared along its source, and water is brought by a ditch from the nearest stream. At about 6 ft. down the water begins to rise from the soil, and to get rid of this, and also to utilize the water from the stream as a motive power, an ingenious chain pump is made by constructing a long wooden trough of three planks, each 100 ft. in length, and this is placed with one end resting on the bank, the other sloping to the water in the lowest part of the mine. A wooden chain, with its small oblong pieces of wood placed at right angles to the line, is fitted accurately into the trough. The wooden chain is endless, and is passed round two wheels—a small one at the lower end of the trough, and a large one at the upper end. The latter is a water-wheel, and is turned by a constant stream of flowing water. Round the axle of this wheel are cogs, each of which in turn, as the wheel revolves, draws up a link of the endless chain through the trough, and, as each joint fits accurately into the trough, they bring up in succession a quantity of water, which on reaching the mouth of the trough falls into the channel by which the water which turns the wheel is carried off, and is thus also taken away out of the mine and conducted to the next, when the process is repeated. The small wheel at the lower end of the trough regulates the chain, and guides the wooden joints into the trough.

The Chinaman's tools consist of a hoe, two baskets, and a bamboo pole. The soil is scraped with the hoe into the baskets, which in turn are balanced over his shoulder at the ends of the bamboo pole. The washing is performed in much the same way as placer gold is washed in California and the West. The soil is thrown into a trough filled with running water, in which the dust is carried off in solution and the ore retained by wooden bars nailed across the bottom of the trough.

While the Chinese system of smelting is similar to that of the Malays, it is more elaborate, and carried out on a much larger scale. In place of the bamboo bellows a very ingenious plan is adopted. The trunk of a tree, about 18 in. in diameter and 10 ft. long, is carefully hollowed out and closed at either end. A long pole with a circular piece of wood at one end, fitting exactly into the bore of the tube, acts as a piston. In order to secure the tube being perfectly air-tight, the end of the piston is well padded. Valves are placed at each end, to allow the air to enter, and the center of the nozzle of the bellows communicates with the furnace by a small air passage. On the piston being drawn out, the air in the higher portion of the tube is forced down to the nozzle, and, being drawn back, the air in the further part of the tube is similarly drawn into the furnace. The charcoal is soon brought to a white heat and ready for the molds. The best of the Chinese mines are found in Laroot, in the northern part of Perak, south of the Siamese State of Quebrada, in a stratum of whitish clay. In some of the tin mines in the neighborhood of Batang and Padnay rivers small quantities of gold are found mixed with tin. Consul Wildman says that the Jelebu Tin Mining & Trading Company is the only successful European managed mining adventure in Malays, and one of the chief producers of Straits tin.

REGULATION OF THE TEMPERATURE OF PASSENGER CARS.

To the Editor of The American Engineer and Railroad Journal:

I read with considerable interest your article in the April number on "Comforts of Railroad Travel." The item that interested me most, however, was on the temperatures maintained in cars during the cold weather. Traveling as I do many hundreds of miles during the year, I have experienced all the fluctuations of temperature that a thermometer is capable of, and have often wondered why some automatic regulator has not been put in use that would maintain an even temperature, especially in sleeping cars. Such regulators are in successful operation on furnaces and where steam is used in cities. Cannot they be applied with equal benefit to railroad cars? Perhaps if you ventilated this question fully in your valuable columns it would result in the relief of a suffering traveling public.

Very respectfully yours,

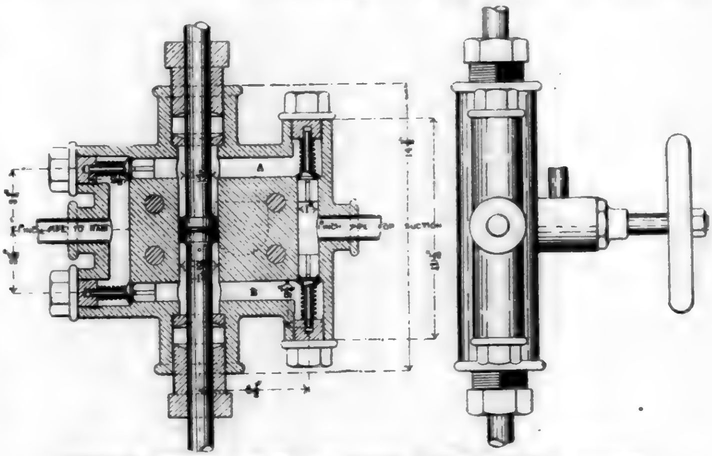
Oliver E. Stanton.

Brooklyn, N. Y.

MALLET SYSTEM OF DUPLEX COMPOUND LOCOMOTIVES.

By J. A. Maffei.

The duplex compound locomotives, as constructed according to the Mallet system, are composed of two distinct groups of twin steam engines, a high-pressure and a low-pressure one,



PUMP FOR HYDRAULIC PRESS, DELAWARE & HUDSON CANAL COMPANY.

which are both arranged under a common locomotive boiler. The high-pressure engine with its main framing is made in a fixed connection to the boiler, while the low-pressure engine, which is placed at the front end and supplied with exhaust steam from the high-pressure cylinders, is made to swivel under the boiler.

Thus, the high-pressure steam pipes leading from the boiler to the respective cylinders are made a fixture, like in ordinary locomotives, and there is only a movable pipe—forming receiver—connecting the two cylinder systems, also a movable pipe leading from the low-pressure cylinders to the blast pipe.

Unlike ordinary compound engines with uneven cylinders, the duplex compound locomotives, with two pairs of symmetrical cylinders fore and aft, work very steady, with even piston pressures on both sides of the engine, and there are no difficulties at starting.

The engine weight being subdivided over a greater number of axles and a longer flexible wheel-base, there is, besides, less internal engine friction, less straining of the permanent way, this being one of the characteristic advantages of the system. As compared with ordinary engines, the duplex locomotive permits the employment of a lighter rail, or with a rail of a given weight the tractive force may be doubled.

The two steam engines proper are built with outside cylinders and motions and are mounted on an equal number of coupled axles. As the front engine is made to swivel under the boiler, the framing of the locomotive is made of two distinct parts in such a manner that the front framing is coupled or articulated to the hind framing by means of a strong vertical hinge. The hind or main framing, which carries the firebox, is curved upward over the front engine and supports likewise the boiler shell and water tanks, while the framing itself rests by means of suitable slides upon the front engine framing, which is thus enabled to move freely in a horizontal direction. In order to prevent a too great mobility of the front engine a pair of check springs bearing against a support underneath the smoke box are provided.

The valve motions of both engines are made identically in all their parts. The stationary links are of the "Walschaert" type, and as the volumes of the high- and low-pressure cylinder systems are proportioned for an equal admission of steam, the reversing of the duplex locomotive is effected by a single screw as in ordinary locomotives. The reversing screw acts upon a lever commanding the motions of the hind or high-pressure cylinders; from this lever and by means of an intermediate lever and shaft fixed in the prolonged main framing, also by an articulated tie-rod, the lever commanding the low-pressure cylinder motions is actuated.

At starting the duplex locomotive the boiler steam is admitted to the high-pressure cylinders only; the exhaust steam from these cylinders then fills the receiver, exercising a certain amount of back pressure upon the high-pressure pistons, and actuating at the same time the low-pressure cylinders. The steam pressure in the receiver is limited to 70 lbs. per square inch, there being safety valves provided, which prevent the accumulation of a higher receiver pressure. The boiler pressure amounts from 175 lbs. to 200 lbs., according to circumstances. It should be borne in mind, also, that the receiver forms a kind of pressure regulator between the two cylinder systems; thus, if the front engine should slip there would be immediately a corresponding decrease of pressure in the receiver, while in the case of the hind engine slipping, the reverse would take place. In both cases either engine will cease slipping without the regulator being touched. If necessary, the starting of the locomotive can be facilitated at certain positions of the high-pressure pistons by admitting live boiler steam to the receiver, and this can be done automatically by connecting the auxiliary steam cock with the reversing gear.

The duplex locomotives are fitted with hand brakes in combination with the Westinghouse, or any other system of continuous brake acting upon both engine groups.

As a rule these locomotives are built as tank engines, with total adhesion, the coal bunker being at the rear; but where great provisions of water and coals have to be carried, a separate tender may be added.

Mallet's duplex compound locomotives were first introduced and tried upon narrow-gauge lines, and after a prolonged service this type of engines proved to be exceedingly well adapted to solve the problem imposed on such motors—viz., "To propel economically, on a rail of given weight, the greatest possible loads over heavy gradients combined with small curves."

Afterward these engines were built for lines of the normal gauge, particularly for mountain railroads, and, as anticipated, the results obtained were highly satisfactory. In the case of heavy trains of any description, the duplex locomotives can be advantageously employed in lieu of the double traction generally made use of.

In the following table are shown the leading proportions of several types of duplex compound locomotives built for various requirements. With the smallest engines of but 12 tons in working order, portable railroads of 2 ft. gauge with rails of 19 lbs. to the yard have been worked; the engines passing freely through curves of 50 ft. radius, and climbing inclines up to 1 in 12. The heaviest engines of 60 and 85 tons weight are employed on mountain railroads in Switzerland—viz., on the Central Swiss and Gothard lines.

Gauge of Line.	24 in.		30 in.	1 Meter.			Normal.		
Types Nr.	I	II	III	IV	V	VI	VII	VIII	IX
Weight of rail per yard lb.	19	24	30	36	44	47	50	74	74
Number of axles per locomotive	4	4	4	4	4	4	4	4	6
Load per axle on rails. t	3	4	5,5	6	8	10	9	15	14
Weight of engine, empty ....tons	9	12,5	18	19	26	32	28	44,5	67
Weight of engine, full. t	12	16	22	24,5	32	40	[illegible]	60	85
Total heating surface, sq. ft.	250	310	420	450	720	960	840	1140	1670
Grate area........sq. ft.	5,4	6,5	8,6	9,7	11,8	15,5	16,2	18,8	23,7
Diameter of wheels..ft.	2	2,4	2,6	3	3,3	3,5	4	4	4
Rigid wheel base....ft.	2,8	3,3	3,6	3,7	4,5	5 2	4.6	5.5	8,8
Total wheel base .. ft.	9	11	12,3	13	15	17	16,5	18,3	26,6
Radius of smallest curves..........ft.	50	65	80	130	160	200	200	300	[illegible]
Tractive force........lb.	4000	5000	6600	7800	10400	13200	11000	15400	[illegible]
Boiler pressure......lb.	175	175	175	175	175	175	175	200	175
Length of engine with buffers.............ft.	18	20	22	24	29	33	27	34	45

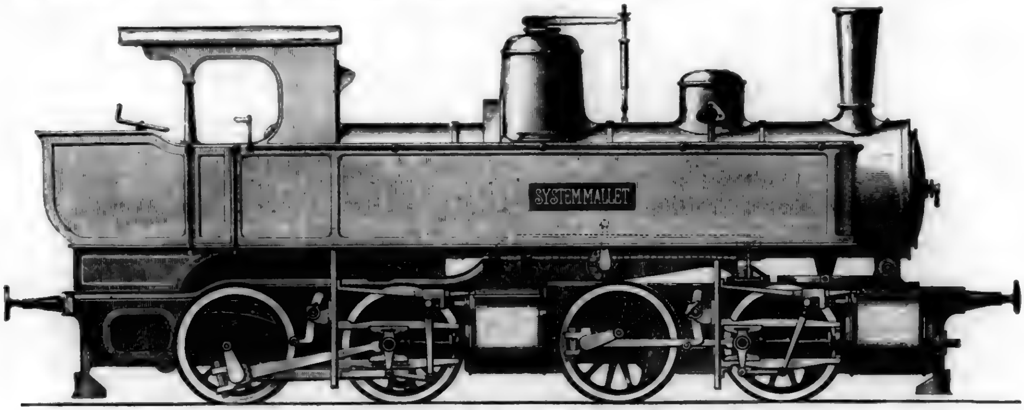
The above types of duplex compound locomotives have proved very successful in each case, and as a consequence the railroad companies using these engines have repeated their orders.

As compared with ordinary engines, the duplex locomotives have effected a saving of from 15 to 22 per cent. of coals by working the same trains and loads. The consumption of lubricating materials is about the same in both cases.

An important feature is the slight wear and tear of the working parts of the duplex locomotive, owing to the fact that the strains or pressures to which these parts are exposed are only half as much as in ordinary engines of the same power.

In order to give an idea, for practical purposes, of the hauling power of the new engines, there will be found in the annexed table the approximate gross loads, in tons, which can be propelled by the different types of duplex compound locomotives. The resistances have been computed at 11 lbs. per ton at a mean speed of 15 miles per hour. The loads are given exclusive of engine weight.

Types Nr.		I	II	III	IV	V	VI	VII	VIII	IX
Tractive force lb.		4000	5000	6600	7800	10400	13230	11000	15400	20000
Gross load hauled in tons on inclines of:	0	350	440	560	670	900	1100	960	1300	1700
	1 : 200	170	200	280	320	440	550	460	600	800
	1 : 100	110	140	180	210	280	350	300	400	500
	1 : 66	80	100	130	150	200	260	210	300	370
	1 : 50	60	80	100	110	150	180	160	220	280
	1 : 40	50	60	80	90	120	150	125	160	220
	1 : 33	40	50	65	70	100	120	105	140	170
	1 : 28	35	45	55	60	90	100	92	110	140
	1 : 25	30	35	45	50	75	90	76	90	120
	1 : 22	25	30	40	45	65	70	66	80	100
	1 : 20	20	25	30	40	55	60	56	70	85



MALLET DUPLEX COMPOUND LOCOMOTIVE.

THE ERICSSON SUBMARINE GUN.

(From *Annual No. XI.* of the Office of Naval Intelligence.)

THE Ericsson gun and projectile, as fitted on board of the *Destroyer*, are shown in the drawings, ready for firing.

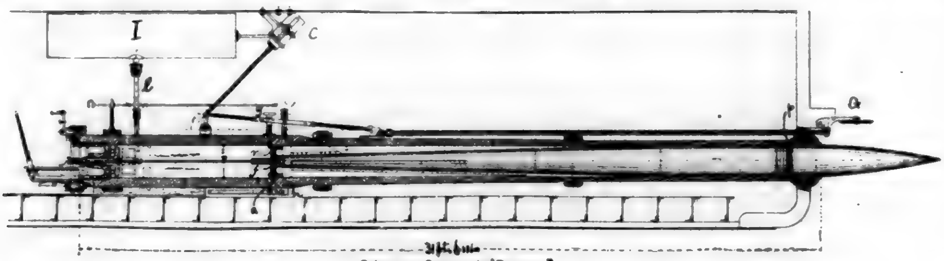
The weight of projectile is 1,525 lbs.; length, 27 ft. 4 in.; diameter, 16 in.; explosive charge, 300 lbs.; propelling charge, 40 lbs. The initial pressure calculated is 4,000 lbs.; mean pressure, 1,692 lbs.; muzzle pressure, 895 lbs.; and the muzzle velocity, 548 ft.

The gun is fitted with a slotted-screw breech mechanism. The diameter of the bore is 16 in., and the chamber is enlarged, there being a decided shoulder at *a*. The bow shutter *G* is controlled by a rod actuated by the compressed air cylinder and piston *C*. The drain-pipe *n* is controlled by a valve; *I* is the compressed air cylinder connected to the gun chamber by the valve and pipe *l*, and *y* is a set-screw stop.

The projectile is made in three sections, for convenience in handling and stowing, which are connected up before loading. It is fitted near the head with a leather grommet, *p*, and has horizontal and vertical tail fins.

The piston-head *f* has a hollow stem screwed into it which, is slightly longer than the propelling charge, and is provided with spring packing rings which cause it to fit neatly during its passage through the bore or the chamber. It has a center recess in its front face, is seated the tail end of the projectile, to which it is secured by a set screw. On its rear face is a soft metal annular ring of such diameter that it admits of passage through the enlarged chamber, but is greater than the diameter of the bore.

The working of the gun is as follows: The bow shutter *G* being closed, and the water drained out of the gun through *n*, the breech is opened and the projectile, on a carriage in line with the gun, is run into the bore until the tail just projects to the rear. A piston-head is then fitted to its tail, and the set screw is tightened sufficiently to keep it from turning, but loose enough to allow it to slide off when it meets the resistance of the water. The projectile is then shoved further home, until its base is in the position shown by the dotted lines in the figure, at which time the washer *p* will fit the bore snugly. The powder charge centered in the bore on the legs of its case is then inserted, the electric primer fitted, and the breech closed.



Submarine Gun for the "Destroyer."

The shutter *G* is opened; then the valve *l*, admitting compressed air in rear of the piston *f* and forcing it and the projectile forward in the bore, to the position shown in the figure. The forward movement is stopped, in this position, by the annular ring on the rear face of the piston taking against the shoulder *a*. The stop-screw *y* is then screwed down as a safeguard to prevent the projectile from being forced in by the water pressure, should it from any cause exceed that of the air pressure.

The valves *n* and *l* are then closed and the gun fired. The pressure of the powder gas causes the annular base ring of the piston to curl back when forced against the shoulder *a*, and thus cupped it allows of forward movement, at the same time acting as an additional gas-check. Upon entering the water the piston-head falls off, free from the projectile. The shutter *G* is then closed, the drain-cock *n* opened, and, when freed of water, the gun is ready for another charge.

Experimental firings have lately been conducted by the Torpedo Board with the gun fitted to the *Destroyer*.

The boat was moored 100 ft. from the dry dock, in which were suspended six nets 40 ft. long by 20 ft. deep, each 100 ft. apart, their centers being in the center line of the dock. Firing thus into the dock insured the recovery of the projectiles to facilitate investigations as to the causes of possible erratic shots.

"Twenty shots have thus far been fired, one of which was with a special automatic projectile. The firing charges employed have not exceeded 30 lbs., although the gun is designed to withstand charges of 40 lbs.

From the results thus far attained it is safe to say that the experiments have demonstrated the possibility of firing a submarine projectile 600 ft. by powder discharge; that up to that range the vertical danger space is from the surface to a depth of 22 ft., and the lateral accuracy sufficient to strike a vessel 50 ft. long.

The explosion of such a charge of high explosive, even at the water-line of a vessel, if not proving fatal would certainly do very great damage.

THE SELECTION AND TREATMENT OF STEEL FOR FORGINGS.

AT a recent meeting of the Leeds Association of Engineers Mr. Francis Rixon, of Sheffield, read a paper upon the above subject from which we extract as follows:

"Before the invention of the Bessemer process of making steel, and for some time after, until confidence in that material was established, fagoted iron was the only material available for engine and machine forgings, and notwithstanding its tendency to establish seams, and evident laminations, it served its purpose admirably, and even now, in the presence of mild steels of the highest excellence, an excellence far beyond the hopes of their several inventors, it continues to hold its own. For all difficult shapes where steel castings are not permissible, and where piecing up after partial machining is necessary, and, further, where 'case-hardening' is called for, a good iron is essential, and will hold the field in its proper sphere.

"Then, for the screw shafts of steamers and piston-rods for steam-hammers, iron lasts longer than steel, unless the latter are oil-tempered before using. An iron rod in one of our hammers was in constant use over 13 years, and is now good, but kept as a duplicate. I never heard of a steel rod half that age; it will probably have made 7,000 tons of steel forgings up to its replacement. Still, there are many purposes for which steel, carefully selected and judiciously adapted to the duty to be done, presents such features of excellence as no other known substance, commercially available at a reasonable price, can be said to possess; its uniform texture, its freedom from seams and impurities, its wearing properties, and the ease by which it can be tooled and polished, mark it out as the ideal metal for the moving parts of both heavy and light machinery.

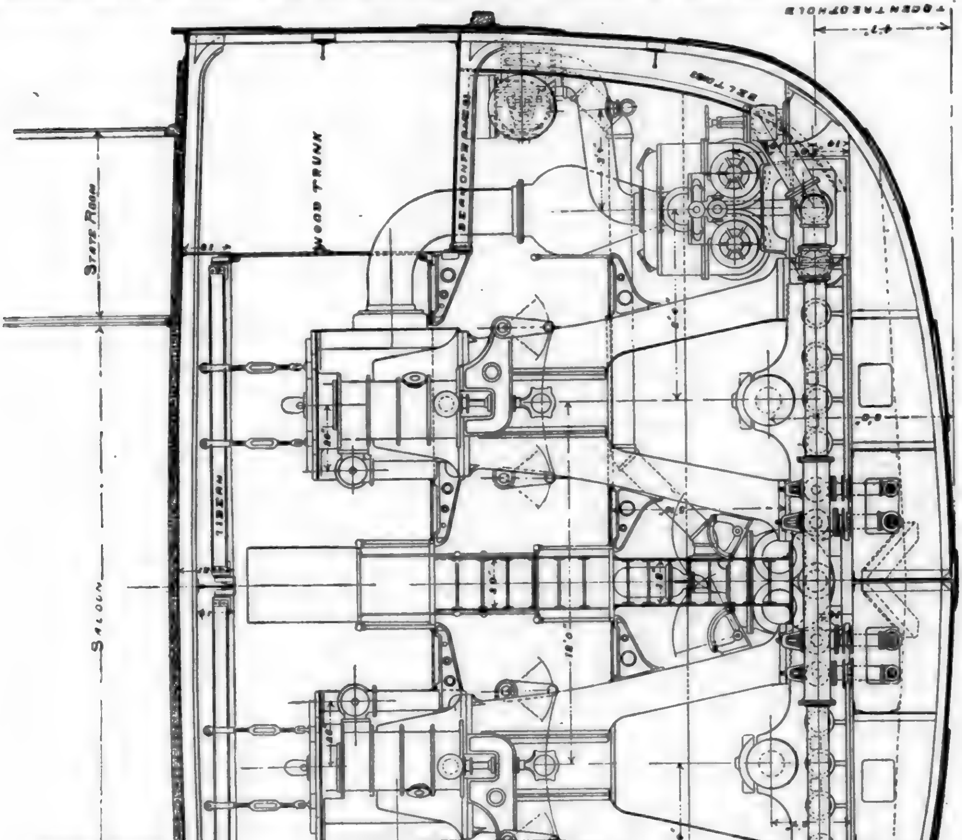
"There are several methods of making mild and other steels for mechanical and kindred purposes (and I purpose to-night to refrain from mentioning the crucible process), but for high-class work engineers and technical experts generally agree that the Siemens process is the one most reliable; its earlier sister process, the Bessemer method, to which the world owes much, not only to Sir Henry Bessemer, but also to Mushet, whose spiegeleisen made the blown, or decarbonized, metal malleable, but also to Heath and other workers, whose names do not often appear in the light they deserve. Where quantity is the first consideration, the Bessemer process is vastly superior, but where nice gradations of temper and quality are imperative, the Siemens is indispensable, as frequent tests can be taken and variations made in the composition, until the exact point is reached which the specification being worked to calls for. There is also the more recently developed basic process both in Siemens and Bessemer practice, but as those yield a class of material for constructive and commoner purposes, they do not fall within the scope of these remarks.

"The steel best adapted for forgings, such as piston-rods

of engines, main engine shafts, marine cranks, and other parts subject to severe torsional strains and carrying heavy loads, should be of such a nature as to give a tensile stress of 27 to 30 tons per square inch, with a high percentage of elongation, say 35 per cent. in 2 in., and a reduction of area of, say, 45 to 55 per cent. A bending test 1 in. square, 10 in. long, should bear bending over a round bar 1½ in. diameter and it should bear closing thus ⊂ and show no sign of fracture. For special cranks for high-speed engines a steel of higher tensile strength is desirable, and 34 tons tensile, 28 per cent. elongation, and

from blemishes than the softer grades of material. Perhaps the best proof of this is to be found in the punishment or fatigue test, described at the end of this paper—a test which leaves no doubt of the capacity of the material to resist such shocks as may be expected in use.

"The falling test is one on which public engineers rely almost as much as on the tensile test. Select a forged steel bar, say 3½ in. diameter and 5 ft. long, place it on supports 3 ft. apart, drop a tup of 1,120 lbs. on it from a height of 20 ft., continue the blows until an angle of 90° is reached,



SECTION THROUGH ENGINE ROOM OF STEAMER "VIRGINIA."

52 per cent. reduction gives excellent results, especially when used in white metal bearings; it never licks up the metal.

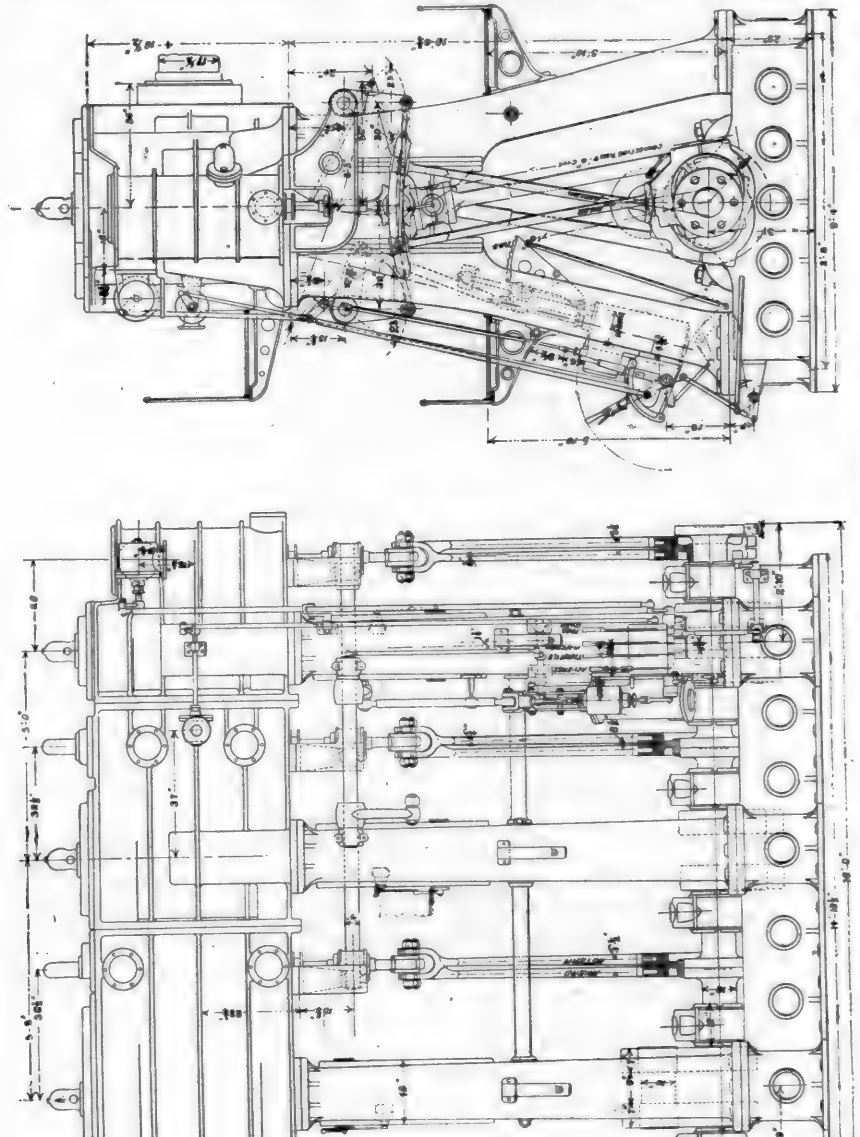
"It is not necessary to define the chemical composition of an ideal forge steel, as good results can be, and are, produced by different methods; but I prefer a stiff steel of good quality to a soft steel of low character, and I always question the judgment of engineers who stipulate that their forgings should be made of steel under .15 carbon. My own opinion is that about .30 is better in every way, and is certainly more free

then press the ends toward each other until this curve is reached ⊂ without fracture. A railway axle of the usual shape, 4½ in. diameter in the middle, bore six blows of 20 ft. each, from a tup 1,650 lbs., without breaking; and a further blow of 38 ft. broke it. Another axle, 4¼ in. diameter, bore six blows of 20 ft. and 11 blows of 40 ft. without breaking; after this seventeenth blow (it being warm from concussion) it was cooled in ice and snow, and broke at the eighteenth blow—and no wonder. An iron axle was next tested, 4¾ in.

diameter. The test specified was six blows from 25 ft. It broke at the fourth blow, showing a coarse, dirty fracture. A steel axle, same size, bore six blows of 25 ft., and also 20 blows of 40 ft. These particulars show the wonderful tenacity of a good steel forging, and when it is remembered that good steel is cheaper than good iron, the difference in strength, as an equivalent of money, is the more remarkable.

"As a result of excessive vibration, iron and steel are liable to 'tire,' and become flaky or granular; and the late Mr. Robert Hadfield once showed me a bar of iron which had been subject to some thousands of sharp blows—a piece was easily broken from the 1½ in. round bar by a hand hammer. The flakes were something like the scales of a roach. The other piece of the bar had been re-heated and thrown down to cool, and its fracture was fibrous, like an ordinary piece of new iron. Before leaving the question of material, I may say that Siemens steel is now being made from .09 carbon up to 1.50 per cent. The latter is used for fine files with great success, while tempers of .75 to .95 make wonderfully good saws and springs; indeed, so successful has this become, that common crucible steel is a thing of the past.

"And now, having described the nature and quality of the material for forgings, a word as to treatment. Much depends upon the manner in which the heating or furnacing is carried on. The heating should never be rapid; time should always be given for thorough soaking through, or wasters are a certainty; and you all know how disappointing it is, sometimes disastrous, to find days and sometimes weeks of turning are lost by a flaw appearing just when the job is apparently done. Hammering should never be too rash at first; it segregates the



PORT ENGINE OF GOODRICH LINE STEAMER "VIRGINIA."

particles and weakens the piece. On the other hand, cold hammering is objectionable, as tending to brittleness. Steel so treated needs to be, and ought to be, annealed as also should all forgings made in bosses or dies to exact shapes, else, when at work, they are liable to expand and fret their bearings.

"There is another method of making forgings, which has budded and faded more than once, to which reference may be made—viz., the use of piled scrap steel, which is fagoted into blooms, re-heated and swaged. The process was first applied at Dumbarton, later by the Mersey Forge, who rolled down ingots into flat slabs, and piled and welded them for cranks and other important work. Railway companies also use this plan for side-rods, draw-bars, etc.; the resulting forgings ring under a stroke of a hand hammer, same as steel, but a fracture looks like iron. I do not approve the use of this process generally, believing the forgings would be affected by extreme frost, and be, in consequence, dangerous, especially for draw-bar hooks, on account of the sharp snatches they have to endure. I think it best to pass the steel plate scrap through the Siemens furnace, and use new ingots.

"In connection with this subject, I may allude to the importance of the drop stamp for producing small forgings in large quantities. The saving over hand-made articles is remarkable, but not more remarkable than the greater excellence of the product. The principal factor in this process is the dies, which must be made of very good material and exact workmanship. The next point to observe is the selection of a good soft material, which will bear forcing into the desired form, without breaking up; and a most important feature is that the guides are true, or the trimming after the stamp will be very troublesome. It sometimes happens in the manufacture of important steel forgings that, in spite of great care, internal defects will exist in the interior of the piece. These defects are generally to be traced to the existence of gas or air bubbles in the ingot, which hammering and rolling do not remove, but usually aggravate, by driving the occluded gas in various directions. Now, this subject has occupied the minds of several good metallurgists, but the remedy is, in the main, as far off as ever. Whitworth employed the hydraulic pressure on the fluid steel as a remedy, but it is extremely expensive in practice, and has not been generally followed.

"Another branch of the business of forging is that known as bending prepared bars of forged steel or iron into bent cranks by using the hydraulic press. It means a great saving of time and labor, and when numbers of a given type and size are called for, and a powerful steam stamp associated with the press, cranks of the best shape and finish can be produced at very low prices, the principal outlet being in the direction of portable and kindred engines and for gas engines. This process was first employed only for the manufacture of cranks having a sound section, but since 1884 the firm of which I am a member turned their attention to making bent cranks, having the same configuration as forged slab cranks, at the same time providing for the fiber of the material to be continuous throughout the piece, and at the same time to avoid the delay and labor inseparable from the drilling and slotting of slab cranks. This process is now in daily operation for locomotive and electric-lighting engines, and also for marine and mill engines, and is giving great satisfaction.

"It may be said that wonderful mileage has been got out of locomotive axles by the older method; indeed, recent cases have come under my observation showing 750,000 miles run; but it is very frequently the case that new axles go in their first year, and in many cases the causes are due to want of work on the vital parts. Numerous 'cripples' recently examined show fractures on the underside of the crank-pin, the next in order show weakness on the inside web, and others fail from the strain of twisting by wrenching the webs from a straight line to right angles at the forge. I ought to speak cautiously at Leeds on this subject, but I am convinced that the present practice of locomotive crank-axle making is wasteful, clumsy, and expensive, giving the worst results at the maximum expense.

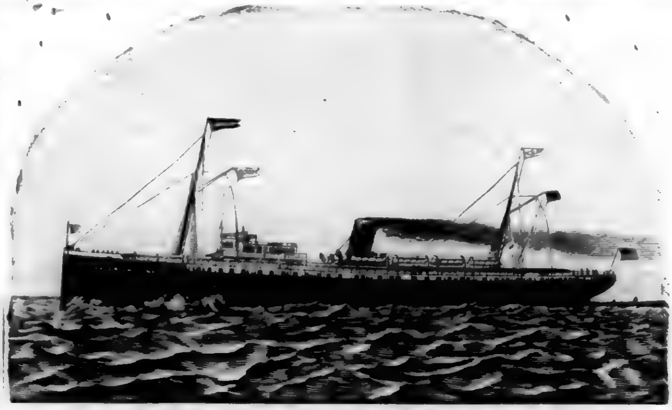
"Intimately connected with steel forgings is the practice of tempering in oil, in order to increase the toughness of the article so treated. Locomotive axles are often oil-tempered, as are the inner tubes and trunnions of large guns, while smaller guns are heated entire and quenched vertically in a bath of oil, the oil vat being itself immersed in cold water, sometimes artificially cooled, so as to keep the oil at proper temperature. Steel, which in its normal state will bear a maximum load of 31 tons, will, after heating and quenching in oil, carry 43 tons tensile, and gun barrels after such treatment are re-heated sufficiently to reduce the tensile to 37 tons, which gives excellent practical results. In this state the metal works very sweetly. I recently saw a turning, 268 ft. long, taken from an oil-tempered steel gun barrel. Where high results are desired, and price no object, the oil tempering is a very good thing, but, like other good things, it costs money.

FATIGUE TESTS ON CRANK STEEL.

A piece of the steel planed out of the solid, 1½ in. square, and 12 in. long, is placed upon supports 6 in. apart, and a tup weighing 1,120 lbs. is dropped from a height of one foot upon the specimen, and the piece turned over after each blow.

Mark on Specimen.	Description of Material.	Maxim. Tensile per Square Inch.	Elongation Per Cent in two Inches.	Reduction of Area Per Cent.	No. of Blows before Distress.	Total No. of Blows.	Remarks.
25	Ordinary forging steel	29.0	35.22	53.50	23	25	Deflected freely under drop.
45	Admiralty crank steel	27.3	31.50	52.40	39	45	Deflected freely under drop.
57	Fluid compressed steel	33.65	33.00	58.50	49	57	Deflected freely under drop.
78	Special W. & R. crank steel	34.00	33.00	56.80	73	78	Deflection much less than the others.

"Another subject in connection with forgings is that of the proper allowance for tooling. This is a question on which all the doctors differ, and can best be solved by the application of a little common sense. Engineers will ask for three-sixteenths on a double crank, and others will allow half an inch on a plain bar of similar size. Both are wrong; a very good rule for articles having but one setting is to allow ⅛ in. up to 5 in. diameter, ⅜ for 6 in., 7 in. and 8 in., ½ in. for 10 in., and 1 in. for 1 ft. Most turners will agree that an allowance sufficient to clean up the forging all over is more easily dealt with than a closely forged shaft, which has to be humored in the lathe, and requiring its centers altering several times. Given a good lathe, a good man, and a straight forging, no one need complain if an extra eighth has been left on by the forgeman."



STEAMER "VIRGINIA" OF THE GOODRICH LINE.

THE TWIN SCREW STEAMER "VIRGINIA."

The illustrations on pages 228 to 230 give a very good idea of the general external appearance of the twin screw steamer *Virginia* of the Goodrich line, together with the method of construction both of the hull and the engines. The dimensions of the vessel are: Length over all, 277 ft.; length of keel, 264 ft.; beam, 38 ft.; molded depth, 25 ft. She was built by the Globe Iron Works Company, of Cleveland, O., in

1892. Electric lighting on the Mather system is used throughout. There are two Mather compound wound dynamos, ring type, with a capacity of 400 lights each. The switch-board is fitted up with magnetic vane ampère meters and volt meters, circuit distributing blocks on slate bases. The circuits are so arranged that the lighting in different parts of the ship can be controlled on the switch-board, special circuits being run for night and day service. All chandeliers, ceiling lights, and side lights are controlled by switches and all circuits are alternated, so that one-half of the lamps or the whole can be lighted, and in case a fuse should blow out in a circuit the other half of the lamps will remain lighted. The loss on the circuit is less than 2 per cent., and the insulation resistance, with fixtures, dynamos, sockets, lamps, and everything connected, is over 270,000 ohms. A powerful search-light is located on the foremast.

The engines, one of which we illustrate by a full-page engraving, are of the triple expansion type, with cylinders 20, 32, and 52 in. diameter by 32 in. stroke. There are two double-ended boilers 13 ft. in diameter by 22 ft. in length, which are allowed by the Government inspection to carry steam at 160 lbs. pressure. They are equipped with 12 furnaces, each 40 in. in diameter. The fire-hold is air-tight and is supplied with two fans for a forced draft having a capacity of 30,000 cub. ft. of air per minute.

The hull is built entirely of steel, and the lines are so molded that with ordinary weather and a forced draft 22 miles per hour is obtained, while 20 miles per hour is run with the natural draft.

MECHANICAL FLIGHT.

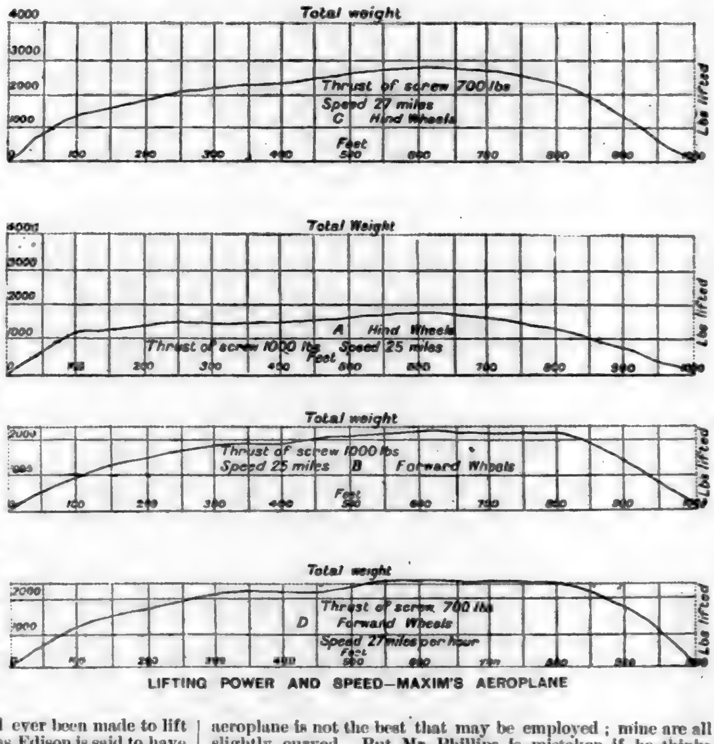
By Hiram S. Maxim.

I notice in a contemporary scientific journal an article entitled "Mechanical Flight," in which certain very interesting experiments which are being tried at Harrow by Mr. Phillips are described, and in which also some allusions are made to myself and my experiments. About two years ago in some articles which I wrote for the magazines, I pointed out that when flying machines were made successful their first great use would be for military purposes, that they would be employed for carrying high explosives and for dropping them into the enemy's lines and country, and that if the French were the first in the field it would be for them a machine for the rectification of the map of Europe. Ever since that time the newspapers of the whole world have been describing me as wishing to drop dynamite into English towns, and in a late article, St. Paul's and Woolwich Arsenal are suggested as points of attack. I am not so bloodthirsty as I am represented to be, and I have no personal designs against any country that I know of; but I do not believe that the millennium is at hand, or that the time has yet arrived when wars may be considered as completely at an end. The Russians believe that the time is not far distant when they will dominate the whole of Europe and a large part of Asia, while the Americans are firm believers in "manifest destiny," the doctrine which is so beautifully set forth in the spread-eagle Fourth of July orations. It means America for the Americans, in fact, the whole continent and all the adjacent islands. Of course these changes cannot be brought about, or, indeed, attempted without war; and if we are to have war and the flying machine is to become a reality, I feel convinced that it cannot fail to be the principal engine of destruction in the future. Up to four years ago I do not believe that any aeroplane had ever been made to lift more than two or three ounces. Thomas Edison is said to have tried the experiment of lifting with a screw, but only succeeded in raising 4 lbs. with a 1-horse motor. Three years ago Professor Langley tried a remarkable series of experiments with the aeroplane and screw propulsion, and although the load which he carried only amounted to a few pounds, he carried at the rate of 250 lbs. to the H.P. Three years ago I also tried a series of experiments with a very perfect apparatus, provided with all sorts of dynamometers, tachometers, and measuring apparatus. In these experiments I carried 133 lbs. to the H.P., though in some cases, with a high velocity and a plane set at a low angle, I approached very nearly to Langley's figures.

According to the article referred to, Mr. Phillips has been at work 27 years on flying machines, and it is claimed that he has actually succeeded in lifting about 400 lbs. practically clear of the ground, but no mention is made of how much power was consumed in accomplishing this. It is also stated that he succeeded in raising "very nearly 3 lbs. per square foot of wing surface, which we imagine is far beyond any result yet obtained."

From the article it would appear that Mr. Phillips is not a believer in the aeroplane system. I am quite willing to admit that, everything else being equal, a greater amount of lift in proportion to the area of the planes and the power consumed may be obtained with a large number of superposed planes than when the same amount of surface is all in one plane, approximately square in shape: but small planes one placed above the other would not afford protection against a very rapid descent in case of breakage of the machinery. Moreover, a properly constructed aeroplane may be made to lift considerably more than 3 lbs. per square foot. In my first experiments I succeeded in carrying 8 lbs. per square foot of aeroplane, the planes being 13 in. wide and 6 ft. long.

Again, "Mr. Phillips has found that anything approaching a flat surface is useless for supporting heavy weights in the air. In small experiments, where the weight to be raised only amounts to a few ounces, and where a relatively large area may be employed, surfaces approximately flat may be secured; but in a flying machine capable of raising hundreds of pounds instead of ounces, it is impossible, Mr. Phillips maintains, to secure plain surfaces for sustainers having the proportion of 1 sq. ft. for each pound raised." It is quite true that a flat

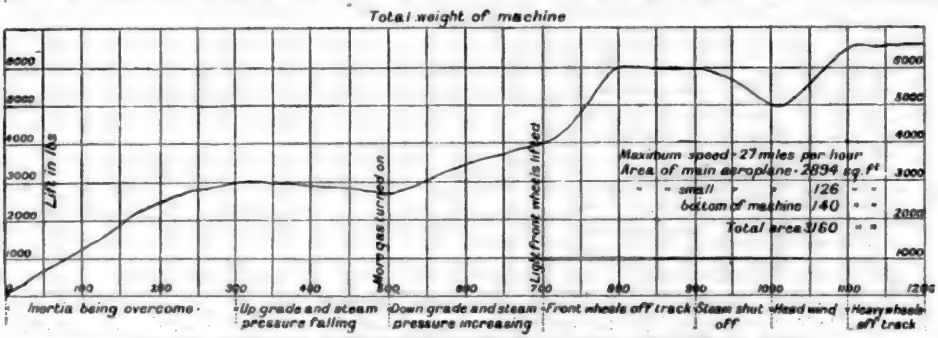


LIFTING POWER AND SPEED—MAXIM'S AEROPLANE

aeroplane is not the best that may be employed; mine are all slightly curved. But Mr. Phillips is mistaken if he thinks that large weights cannot be raised by properly constructed aeroplanes, as the following will show. In my experiments

with the whirling table traveling round a circle 200 ft. in circumference, I found that a wooden plane would easily carry more than 100 lbs. to the H.P., but when I came to stretch textile fabric on a frame, I found that I could not carry more than 40 lbs. to the H.P. Professor Langley admitted to me that he was able to carry a great deal more with flat wooden or metallic planes than he ever succeeded in carrying with paper covered frames This seemed to point to the fact that there was a great deal of drag and waste of power unless the planes were sufficiently rigid to preserve their shape perfectly.

Having finished my whirling table experiments, I commenced on a larger scale, and provided myself with a railway track about 9 ft. gauge and 1,800 ft. long. My machine is of great size, the total weight being about 7,000 lbs. The engines have already developed 300 brake H.P. Two screw propellers are used, each 17 ft. 10 in. in diameter. In my first experiments with this large machine, I found that there was a great consumption of power that did not manifest itself in lift. In order to ascertain what became of the power, I provided myself with dynamometers, tachometers, and dynagraphs, and all the necessary apparatus for ascertaining to a great degree of nicety all the events that were taking place during the short end of the run, not only were the light wheels, the forward end of the machine and the men lifted from the track, but the heavy wheels were also raised, and when the machine came to a state of rest, one wheel sank deeply into the soft ground, and a sudden squall coming up, the machine was tipped over on its side. My overzealous assistants, whose number had suddenly increased to more than 40, commenced at once to pull at the wires, and were not satisfied until they had broken the framework on which the aeroplane was stretched. The diagram *E* shows the total lift on both the forward and hind axletrees during this run. It will be observed that when the machine had traveled 800 ft. the total lift was 6,000 lbs. This was due altogether to the push of the screws. It afterward mounted to 6,500 lbs., but this was due to a head wind. The maximum speed when the diagrams *A* and *B* were made was at the rate of 25 miles an hour; with all the other runs, the speed was at the rate of 27 miles an hour. The machine is provided with a very delicate and accurate apparatus, which shows on a very large indicator the exact speed at which the machine is traveling through the air. During all these runs the principal lift was obtained from a large aeroplane of 2,894 sq. ft. The total width of the aeroplane is 50 ft., and the



MAXIM'S AEROPLANE EXPERIMENTS—DIAGRAMS OF SPEED AND LIFTING POWER

runs which I made. The machine is mounted on four wheels, with springs interposed between the axletrees and the machine. The dynagraphs are attached to the center of the axletree. The drum which carries the paper turns once round in 1,800 ft., and the pencil traces a line on the paper which indicates exactly how much weight is resting upon the wheels. When the machine lifts, the pencil rises, and a very graphic diagram is the result. Diagrams *A* and *B* represent the run which was made about three months ago. Before making the run, the machine was attached to a dynamometer, the throttle-valves between boiler and engine fully opened, and the gas by which the boiler is heated turned on until the pull of the screws on the dynamometer indicated 1,000 lbs. The machine was then "let go" and the steam shut off after running 800 ft.

It will be observed that the maximum lift on the hind wheels was 1,900 lbs., and the lift on the forward wheels 2,300 lbs., which was very nearly the full weight resting on these wheels. But this was not as much as it should have been. Certain alterations were then made in the aeroplane, and the next run was made on the 16th day of February. The machine was attached to the dynamometer as before, and was "let go" at 700 lbs. Thinking that perhaps the lift might be too great, three men and other weight—500 lbs.—were put on to the machine directly over the forward axletree. Diagrams *C* and *D* represent the result of this run. It will be observed that the lift on the hind wheels was increased nearly a thousand pounds, while the lift on the forward wheels was but slightly increased; still if the men had not been put over the front axletree the forward wheels would have lifted from the track. Wishing to make another run with 1,000 lbs. pull on the dynamometer, I attached a pair of additional wheels under the front end of the machine, connected in such a manner that the small and lighter wheels could lift 3 in. from the track and still leave the heavy wheels on the track. Three men were also placed over the forward axletree, and a run was made with 900 lbs. pull on the dynamometer. After the machine had run about 400 ft., the light wheels lifted clear of the track, and when the engines were stopped they came back again on to the track all right. The machine was then run again with 1,000 lbs. pull on the dynamometer. After the machine had run about 300 ft., I noticed that the steam pressure was falling, and I turned on a little more gas, perhaps a little too much. The result was that the speed increased considerably, and at the greatest thrust of the screws at the time of starting was 1,000 lbs. The runs were made with four men, 600 lbs. to 800 lbs. of water, and 200 lbs. of gasoline on board. The total width of the machine when all the aeroplanes are in position is 100 ft. About half of the planes were in position, and the engines were run at about half of their power. The thrust of the screws when the engines are run at full power is 1,960 lbs.

From the foregoing it will be seen that there is no question about an aeroplane being made to lift heavy loads, and where others—except Mr. Phillips—have lifted ounces, I have lifted tons. These measurements have been made with great care, very perfect and accurate apparatus has been employed, and as far as I am able to judge, they are thoroughly reliable. I do not see where any error could have crept in. So far as propulsion and lifting power are concerned, I think we may assume that the flying machine is a *fait accompli*. Difficult problems are no doubt still before us, but I think if I had one of the large American prairies in England to manœver and experiment on, that the whole question might be solved inside of a year.—*The Engineer.*

LAMINATION IN METAL.

Professor John Tyndall contributes something new upon the subject of cleavage as it occurs in crystals, rocks, ice and other bodies; and his studies lead inevitably to the conclusion that lamination results from the operation of the same laws under analogous conditions as those which produce the property known in mineralogy and crystallography as cleavage.

At first one would suppose wax, or baker's dough, to be most unlikely substances wherein to detect any tendency to cleavage; yet it is precisely with these materials, wherein plasticity is a most prominent physical property, that Professor Tyndall has performed experiments that are commanding the attention of the scientific world, and the results of which have an important bearing upon the metallic processes. In these plastic materials and others, such as clay and graphite, Professor Tyndall has proved that cleavage may be developed in as marked a degree as in slate—even the varieties of the latter used for roofing—by the simple application of pressure to the plastic mass. Cakes of wax that have been thus treated are easily split up into regular laminæ, so uniform in character as

to excite the surprise and admiration of those who have witnessed the experiments.

These researches appear to have proved that any material, no matter how plastic or how homogeneous it may appear to be, has within it the condition for the development of cleavage, and that the only external condition necessary to produce lamination is a sufficient degree of pressure exerted in one direction upon the mass. The resulting planes of cleavage will be at right angles with the direction in which the pressure is applied. The philosophy of this effect lies in the fact that, as relates to the cohesion of its particles, no substance is strictly homogeneous; that is to say, the particles, granules or molecules of substances do not possess cohesive power equally in all directions; and hence, when pressure is applied to them, they slide over each other (the sliding surfaces being those of least cohesive power) and move toward a point of less pressure. In the case wherein pressure is applied in one direction only, the sliding will be in a direction at right angles with the direction of the pressure, and thus plates, laminæ or strata are generated in the mass, the limiting faces of these layers having less cohesion than their interior parts.

It is thus that under the action of the rolling pin flaky pie crust is formed. The same kind of stratification is formed in a biscuit, while in bread, the loaves of which are shaped by kneading, this stratification is absent, and a fibrous structure—called by bakers the "pile"—results from the difference in the manipulation. It is entirely indifferent what kind of material is thus operated upon, provided that it will in some degree yield to pressure without crushing into powder; the result of pressure exerted in one direction more than in any other will result in lamination more or less marked. A practical illustration of this kind of action is found in iron and other metals. When iron undergoes the ordinary process of rolling it is taken at a welding heat from the furnace, and the uniformly distributed heat weakens the cohesive power of the particles quite equally throughout the mass; the result is a fairly homogeneous bar or plate. However, in bars the tendency to longitudinal stratification is manifest, and when the bars are cold and cohesion has again been restored to its normal power, it can always be found that iron so produced is stronger longitudinally than laterally.—*American Gaslight Journal.*

HARGRAVE'S FLYING MACHINE.

We have on several occasions noticed the flying machines constructed by Mr. Lawrence Hargrave, and described by him before the Royal Society of New South Wales. All these have been wonderful pieces of mechanism, combining lightness with rigidity in a marked degree, and each has been a distinct advance over its predecessors. The accompanying illustrations show three of the more recent types. Fig. 1 shows the general appearance of these machines. A backbone carries two outstretched stationary wings or aeroplanes, which glide over the air, while in front are two flapping wings, which afford the propelling power. These wings are driven by an engine, whose motive fluid is compressed air, stored in

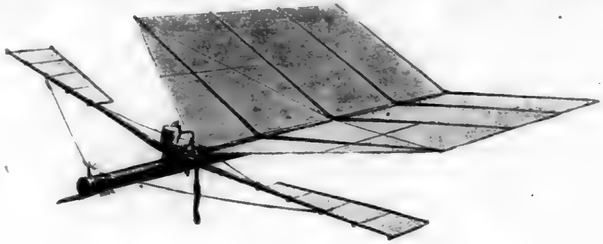


Fig. 1.

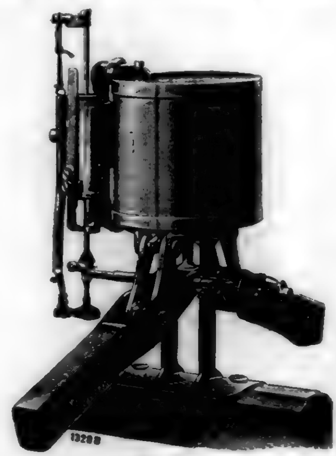
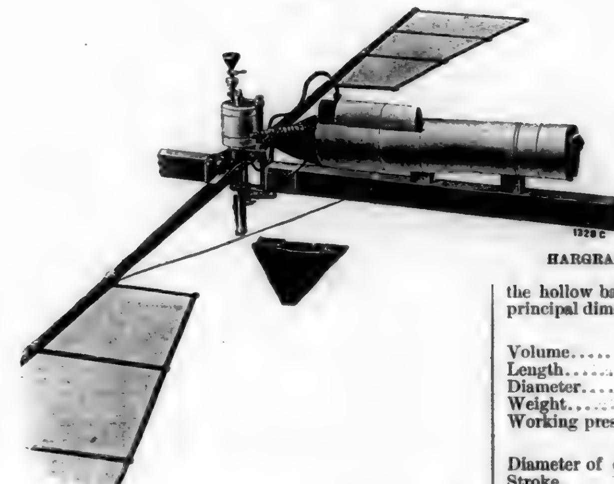


Fig. 2.



HARGRAVE'S FLYING MACHINE.

the hollow backbone of the machine. The following are the principal dimensions:

Pressure Container.	
Volume	251 cub. in.
Length	6 ft. 11 in.
Diameter	2 in.
Weight	15¼ oz.
Working pressure	250 lb. per sq. in.
Motor.	
Diameter of cylinder	2 in.
Stroke	1.28 in.
Reduced pressure	57 lbs.
Weight of engine	11 oz.
Efficiency	.29
Machine.	
Length of wing	31 in.
Area of wings	216 sq. in.
" of body plane	3074 " "
" in advance of the center of gravity	732 " "
Total weight, charged	59 oz.

Five hundred and nine foot-pounds of work produced 46 double vibrations, which drove the machine 512 ft.

Fig. 2 shows another form of engine having a cylinder 2 in. in diameter by 1¼ in. stroke, and working at a pressure of 60 lbs. per square inch. Its weight is 9 oz. The machine fitted with this engine on one occasion flew 343 ft. in 23 seconds, with 54¼ double vibrations of the engine. It was estimated that 742 ft. lbs. of work were done in driving the machine at 10.1 miles per hour.

The success which had been attained by the compressed air motors encouraged Mr. Hargrave to try steam. The conditions he laid down to be fulfilled were that the steam motor should be lighter than the compressed air apparatus, that it

should have a uniform boiler pressure, and flap the wings of the standard size as fast as the compressed air engine and for a longer time. The Serpollet boiler was adopted, and as steel pipe could not be got in Sydney, copper pipe of ordinary trade sizes was procured. Many boilers were made and rejected; the one in the figure is a two-stranded coil, containing 12 ft. of pipe, ¼ in. outside diameter, weighing 20¼ oz., with steam and water connections. Methylated spirits of wine was adopted as the fuel, and was stored in the small cylindrical reservoir shown in the figure. The boiler was inclosed in a cylinder of asbestos card, and the vaporized spirit mixed with air was spurted into the furnace. As much as 6.9 cub. in. of water have been evaporated by 1.7 cub. in. of spirit in 80 seconds, the engine making 182 double vibrations of the wings. The engine was of the usual type, with the addition of a feed pump, 5.2 in. in diameter, drawing out of the reservoir shown detached. The relation between the cylinder capacity and the boiler is:

Cylinder	2.2 cub. in.
Steam and water space of boiler	2.8 "
External surface of boiler	113 sq. in.
Internal " "	71 "

Chronograms showed that 1.66 double vibrations per second were made with 55 lbs. pressure of steam, and 1.8 per second with 75 lbs. A thrust diagram showed that:

2.2 vibrations per second produced a thrust of	.75 lb.
2.3 " " "	.90 "
" " "	1.10 "
" " "	1.25 "

The total weight of the apparatus is 64.5 oz., which includes 12¾ oz. for the strut and body plane, and 5 oz. for spirits and water. By aid of an ingenius indicator it was found that .169 H. P. is developed when 2.35 double vibrations are made per second.

If the machine were loaded up with 10 oz. more spirit and water, it is calculated, from data obtained from previous machines, that it would have a possible range of 1,640 yds. On starting the boiler is empty, and is warmed up by a Bunsen burner; then the spirit-holder is heated till the flame ignites, the flame being maintained by a few shreds of asbestos put into the coil. When the flame is under way part of the boiler gets red hot in a few seconds. Then the wings are moved up and down a few times by hand, squirting about a teaspoonful of water into the boiler, and then the engine starts.

Every one must admire Mr. Hargrave's great skill as a mechanic, and the marvellous patience he brings to this subject of mechanical flight. If it had always been attacked in his spirit it would have escaped much ridicule, and greater progress would have been made. As it is, very great advance has been made during the last two or three years, since the matter has fallen into the hands of skilled mechanics, and further developments are to be looked for.—*Engineering.*

MANGANESE STEEL.*

By Henry M. Howe.

Manganese steel is an alloy of iron with from, say, 3 to 20 per cent. of manganese. Certain varieties of it are extremely ductile, and yet very strong and extremely and unchangeably hard. This combination of simultaneous hardness and ductility is, I believe, quite unique.

Common or carbon steel may be extremely ductile in its annealed state, and extremely hard in its hardened state; while the self-hardening steels are nearly unchangeably hard, but always brittle. I know of no substance, organic or inorganic, except manganese steel, which is at one and the same time both hard and ductile. Indeed, hardness and brittleness usually go hand in hand to such a degree that the word "hard" is often carelessly used in the sense of "brittle." And I believe that not a few of us have, by association, come to regard hardness and ductility as in some way absolutely incompatible.

Manganese steel was discovered and patented by Robert Hadfield, and to him and his son we owe most of our information about it.

Manganese steel conducts both heat and electricity extremely badly, and is but faintly magnetizable.

The influence of manganese on the properties of the alloy is probably profoundly influenced by that of the carbon, which at present unavoidably increases with the manganese. We cannot now make 13 per cent. manganese steel with much less than 1 per cent. of carbon; and we can only guess what its properties would be without this carbon.

Let us consider some of the properties to which I have thus referred, and later the preparation and the uses, actual and anticipated, of this remarkable material.

Its properties vary strikingly with the proportion of manganese which it contains, and with the treatment it has undergone. Except where the contrary is explicitly stated, I confine myself to-night to the alloy containing about 13 per cent. of manganese, in its ductile or "water-toughened" state.

Let us first consider the tensile properties of manganese steel, its tensile strength, both elastic and ultimate, and the ductility which a bar of it displays when torn apart longitudinally or tensilely, as in the most common form of tests for engineering and scientific purposes. The general worth or merit of any particular lot of iron or steel is usually measured by its combination of strength with ductility. I do not now speak of its fitness for this or that particular purpose, but of its general merit. The scientific investigator needs one set of qualities; the poet, a second; the statesman, a third. Nevertheless, there are common standards which we apply to all, as measuring their general merit as men.

In case of carbon steel, at one extreme we have metal of enormous strength, but so brittle and treacherous that the engineer dare not use it. At the other, we have metal of extraordinary ductility, but so weak as to be of little value for many purposes. So, in a rough way, we habitually regard that steel which has the greatest strength for given ductility, or that which is the most ductile for given strength, as the best.

The most common measure of ductility is the permanent elongation which a bar of the metal undergoes when it is pulled in two by direct longitudinal stress; and this elongation is habitually measured in percentages of the initial length of the bar tested. The combination, then, of tensile strength with the permanent elongation on tensile rupture, or, in short, of strength and elongation, is the standard by which I first ask you to judge the excellence of manganese steel.

In fig. 1 I have represented this combination graphically for manganese steel, and for many of the best reported specimens of common or carbon steel. (To distinguish common steel from manganese steel, I shall speak of it in this lecture as carbon steel.) In this diagram the ordinates, or the vertical distances of the several spots from the horizontal axis, indicate the ductility as measured by the permanent elongation undergone by a given test piece prior to rupture; the abscissæ—*i.e.*, the horizontal distances of the several spots from the vertical axis, indicate tensile strength. The little black spots represent the properties of carbon steel, and you note that they fall in a tolerably well-defined band, the elongation diminishing as the tensile strength increases.

Note, however, how greatly the manganese steel specimens excel those of carbon steel in their combination of strength with ductility. For a tensile strength of from 130,000 to 150,000 lbs. per square inch, none of the carbon steels have more than 16 per cent. of elongation; while many of the manganese steels of this strength have an elongation of 45 per cent., and some even of 50 per cent.*

But I think that this combination, which we have been considering, ultimate strength with ductility, is by no means so good a measure of general merit as the combination of ductility with elastic strength, or tensile strength within the limit of elasticity, or, as it is called, elastic limit. The elastic limit measures the power of the metal to resist stress without becoming permanently deformed. It is this, probably, rather than the ultimate tensile strength, that should, and some day will, determine the stress to which the material shall be exposed in practice. The ultimate strength of the material measures the stress, a single brief application of which will tear it apart; the elastic strength or elastic limit seems to measure the stress which, if indefinitely prolonged or repeated, will tear it apart. Now, if this be true, no matter how great the ultimate strength, we should not dare to expose materials indefinitely to a stress as great as their elastic limit.

Therefore, in fig. 2, I have in like manner represented the combination of elastic limit with elongation in case of carbon steel, of manganese steel and of nickel steel. The little spots for carbon steel as before fall in a band running obliquely across the diagram, less clearly defined because of the smaller number of cases.

* A lecture delivered before the Franklin Institute, February 20, 1892.

* Since this lecture was delivered still more extraordinary combinations of strength and ductility in case of manganese steel have been reported. Mr. E. G. Spilsbury found in case of one specimen of wire a tensile strength of 400,000 pounds per square inch, with an elongation of thirty-three per cent. in six inches. An extraordinary case of ductility is reported by the same gentleman. Wire of No. 18 gauge, 0.046 inch in diameter, endured forty-eight twists in a length of six inches, and twenty-two bends. Its tensile strength was 155,000 pounds per square inch, and its elongation seventeen per cent. in six inches. These are picked results; in the first of them an error is possible, though extremely improbable.

Two of the triangles, indicating nickel steel, lie well above the band of carbon steel; but even these are excelled by many of the circles which stand for manganese steel. [Since this lecture was read, other tests of nickel steel have come to my notice, in which this combination is as great as it is in the cases of manganese steel represented in fig. 2.]

These comparisons may, however, give a false idea of the ductility of manganese steel. If two metals elongate in a like manner, the extent of their elongation may be a fair comparative measure of their ductility; not necessarily so, however, when their mode of elongating is unlike in kind. A bar of carbon steel habitually yields when pulled in two by "necking," contracting greatly just about the place where rupture occurs, as shown in fig. 3, while a bar of manganese steel or of brass elongates far more uniformly over its whole length. For some purposes this uniform stretch may be better, for others worse, than the necking and localized stretch of carbon steel; suffice it here to point out that the two are different, and, therefore, not strictly comparable as a measure of ductility; and further, that, thanks to the nearly uniform stretch of manganese steel over the whole length of the test bar, its percentage of elongation may be held to give an exaggerated idea of the metal's true ductility or plasticity.

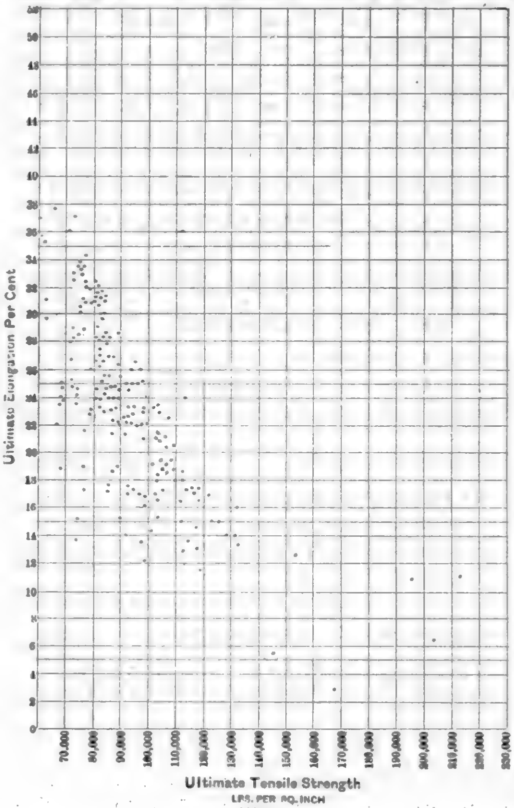


Fig. 1.

0 = Water-toughened manganese steel.
∴ = Carbon steel.

TENSILE PROPERTIES OF CARBON STEEL AND OF MANGANESE STEEL.

This granted, it yet remains that the metal is very ductile and has great strength, both elastic and ultimate.

This leads me to speak of a further peculiarity of the ductility of manganese steel, the difficulty with which cracks are propagated across it—*i.e.*, its non-fissility. This is illustrated by fig. 4, in which are sketched the condition of one and the same test bar of manganese steel, in different stages of elongation under tensile stress. The stretching was interrupted several times, and each time the test bar was water-toughened—*i.e.*, was heated to redness and then plunged in water. You will note, first, the uniform stretch over the whole length of the test-piece, in marked contrast to the necking of carbon steel shown in fig. 3. Next you will notice three rough diamond-shaped figures in each of the lower three sketches. These are deep holes, unexpectedly resulting from the stretching of very light prick-punch marks; one of them is more than $\frac{1}{16}$ in. deep, and $\frac{1}{4}$ in. across. That so hard a material should tear in this way is most surprising. In one case daylight could be seen through a test bar while it was still enduring a tensile stress of over 110,000 lbs. per square inch.

So in testing manganese-steel knuckles for automatic car-couplers, by an impact or drop test, it has been noted that, after the metal has begun to crack, it endures a surprising number of blows before breaking.

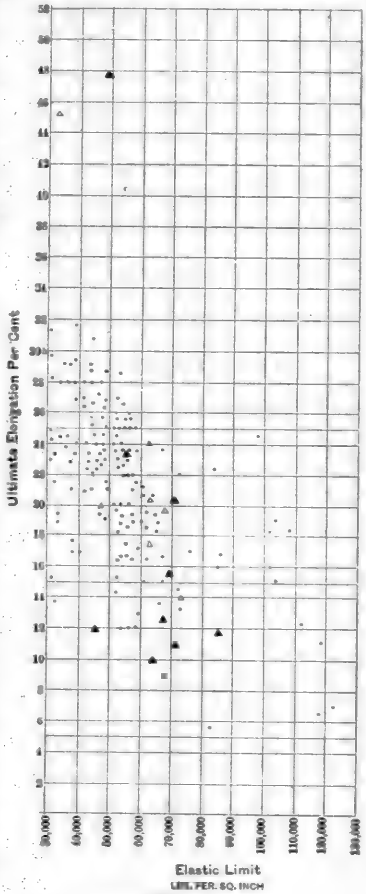


Fig. 2.

· = Carbon steel.
0 = Water-toughened manganese steel.
▲ = Rolled nickel steel.
△ = Rolled and annealed nickel steel.

TENSILE PROPERTIES OF CARBON, MANGANESE AND NICKEL STEEL.

The way in which the tensile strength, and more especially the ductility of manganese steel, vary as the percentage of manganese increases, is very striking. As the manganese rises, the ductility at first diminishes very suddenly. It has long been believed that the presence of 1.5 per cent. of manganese made common carbon steel brittle. As early as 1877 a case came to my notice in which, by an error, a lot of rail steel, which should have contained about 1 per cent. of manganese, actually contained about 1.5 per cent., its composition being normal in other respects. It was dangerously brittle.

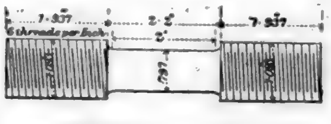
With further increase of manganese, the metal becomes more and more brittle. Manganese steel with from 4 to 6.5 per cent. of manganese, under certain special conditions, is so brittle that it can be pulverized with a hand hammer. But, as the manganese rises above 7 per cent., the ductility of the water-toughened metal increases in a most striking way, till the manganese reaches about 13 per cent. With further increase of manganese the ductility again diminishes, perhaps as fast as it had risen. This is illustrated graphically in fig. 5, by a curve indicating roughly the elongation to be expected in water-toughened pieces.

Fig. 6 shows in like manner how the tensile strength of water-toughened manganese steel, very low when there is some 7 per cent. of manganese present, rises rapidly, reaching a maximum when the manganese reaches somewhere about 14 per cent., and again diminishing with further increase of manganese.

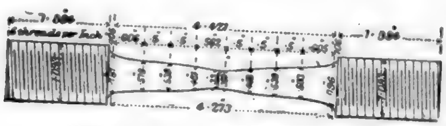
Returning again to fig. 5, we note that the strength and ductility reach their maxima with about the same percentage of manganese.

But, though striking, the reversal of the effects of increments of manganese on the physical properties of the alloy, as its content of manganese rises above 14 per cent., is by no means astonishing; for like cases are reported with other alloys. Thus a slight addition of zinc is reported to lessen the malleableness of copper, while a larger addition in turn increases it.

Fig. 7 compares the combination of strength and ductility of manganese steel with the same combination for



BEFORE TESTING



AFTER TESTING

113.77% ELONGATION

CARBON STEEL BAR BEFORE AND AFTER TESTING

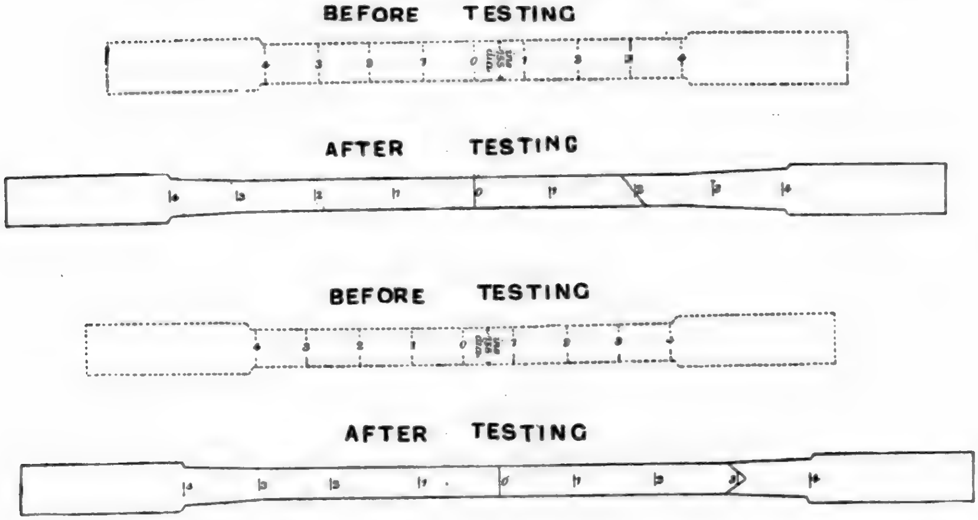


FIG 3 MANGANESE STEEL BARS BEFORE AND AFTER TENSILE TEST

Moreover, the very fact that it is accompanied by great ductility makes its hardness peculiar. We are accustomed to think of very hard bodies as incapable of being indented, as, for instance, by the blow of a hammer; but manganese steel can be thus indented. This, however, is a necessary consequence of its ductility. Most very hard bodies, such as glass, hardened steel or chilled cast iron, if they receive a blow which passes their compressive elastic limit, simply break or crack; that is because they are not ductile; they cannot yield. Manganese steel, however, on receiving such a blow simply yields. Within its elastic limit it behaves under blows like other hard substances. Let the blow exceed the elastic limit, and manganese steel yields where the others break.

I am hardly prepared to give a clear account of its rigidity. Under some conditions it has shown itself very rigid; under others it has not. As yet I cannot point out with confidence the conditions which make it rigid in some cases, but not in others.

Manganese steel car axles, struck transversely by a heavy ram, have been found much more rigid than those of carbon steel, with which they were tested competitively. Yet stamp shoes and horse-shoes of manganese steel have not thus far shown the endurance expected.

In resistance to abrasion alone, manganese steel excels the hard carbon steels (when unhardened) and, *a fortiori*, the soft steels. Where both abrasion and repeated shocks are to be resisted, manganese steel is certainly far less liable to break than the hard carbon steels; but whether, under new conditions combining shock and abrasion, it will prove as rigid as the carbon steels, with which

nickel steel. The circles as before represent manganese steel, the triangles nickel steel. The combination as thus measured is seen to be on the whole much greater in manganese steel than in nickel steel. But this does not at all prove that manganese steel is better than nickel steel.

While manganese steel is intensely and astonishingly hard, considering its ductility, it is not as hard as chilled cast iron, nor as the hardest grades of carbon steel when they are dead hardened, that is to say, brought to their very hardest state by quenching in water. Manganese steel containing some 7 per cent. of manganese, indeed, is so hard that it can be used for cutting iron; and lathe tools made from it have been used successfully. But the 13 per cent. manganese steel, with which we concern ourselves this evening, is far from hard enough for this purpose.

it will then have to compete, direct experiment alone can tell.

Its magnetic properties, or their absence, are among the most surprising things concerning this surprising substance. While manganese steel of 9 per cent. of manganese is attracted by the magnet when finely divided, yet that of 13 per cent. is for all practical purposes unmagnetizable. With moderate magnetizing force, its susceptibility to magnetic influences is, according to Ewing, only about $\frac{1}{4000}$ that of soft iron. "No magnetizing force to which the metal is likely to be subjected in any of its practical applications will produce more than the most infinitesimal degree of magnetization." Yet with enormous magnetizing force, for instance, of 10,000 C. G. S. units, it is possible to magnetize manganese steel very considerably.

If its resistance to magnetization is great, so is its resistance

to the passage of heat and of electricity. Of each it is a very poor conductor.

Fig. 8, from determinations kindly made by the Thomson-Houston Electric Company, of Lynn, Mass., comparing the electric resistance of manganese steel with that of copper and of soft iron at different temperatures, shows that the resistance of manganese steel at 0° C. is nearly seven times that of soft iron, and is very

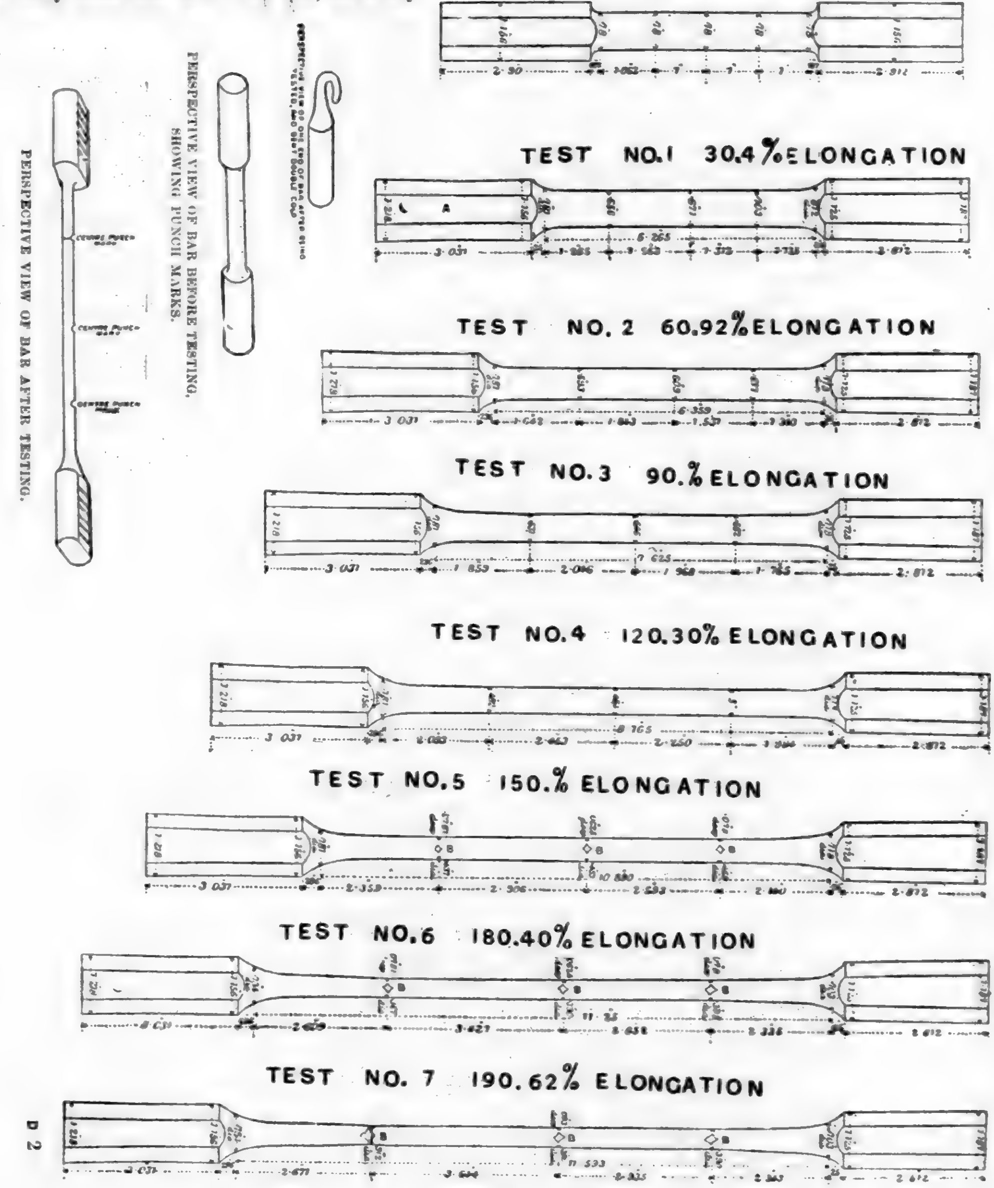


Fig. 4.

APPEARANCE OF A SINGLE TEST-BAR OF MANGANESE STEEL, BEFORE AND AFTER REPEATED STRETCHING, EACH FOLLOWED BY WATER-TOUGHENING.

much less affected by changes of temperature than the resistance of either soft iron or copper. Its resistance is about double that of platinoid, and thrice that of German silver.

Preparation.—Manganese steel of the class that I am describing to-night is made by stirring together the molten, thoroughly decarburized product of the open-hearth or Bessemer process and molten, highly heated, rich ferro-manganese. Care must be taken to avoid loss of manganese, and to keep the proportion of carbon down. The product should have not less than 11 per cent. of manganese, and not more than 1.25 per cent. of carbon. If we can give it as much as 13 per cent. of manganese and less than 1 per cent. of carbon, it will be better for most purposes. So high a ratio of manganese to carbon can be had only through great care.

The high cost of metallic manganese puts it beyond our reach as a material for making manganese steel. The only present available source of manganese for this purpose is the carburetted alloy of iron and manganese called ferro-man-

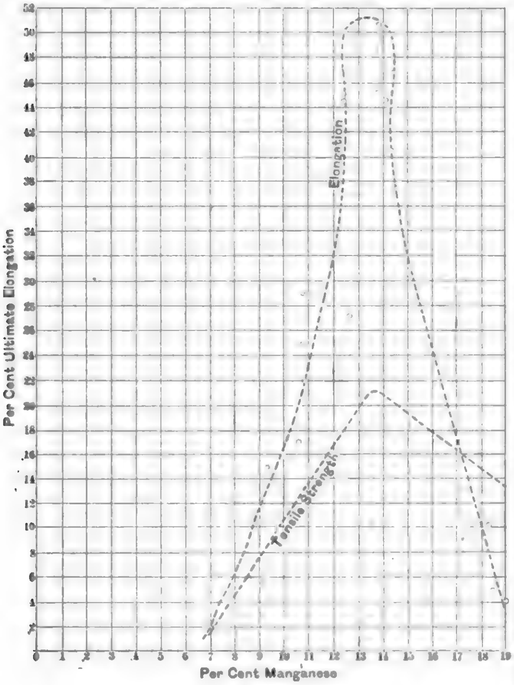


Fig. 5

0 = Water-toughened manganese steel.

INFLUENCE OF THE PERCENTAGE OF MANGANESE ON THE DUCTILITY OF MANGANESE STEEL.

ganese, made in the iron blast furnace from ore of manganese. It usually contains about 80 per cent. of manganese, 6 per cent. of carbon, and 13 per cent. of iron, though occasionally the proportion of manganese rises to beyond 87 per cent., with as little as 7 per cent. of iron.

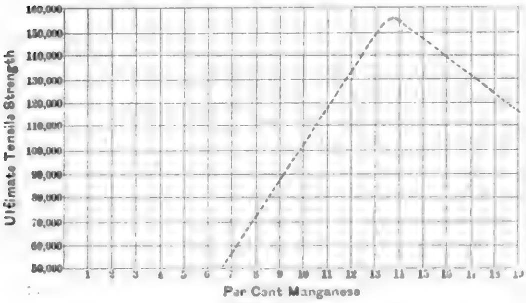


Fig. 6.

INFLUENCE OF THE PROPORTION OF MANGANESE ON THE TENSILE STRENGTH OF MANGANESE STEEL.

These crude products of the blast furnace necessarily contain so much carbon, absorbed directly or indirectly from the fuel, that even those richest in manganese are barely rich enough. The difficulty is to get into the steel as much manganese as it needs, without incidentally introducing an excessive and injurious quantity of carbon. For the requirements just given as to the composition imply that the steel should contain at least nine times, and better 13 times, as much manganese as carbon. Even if we make no allowance for the fact that the molten decarburized iron usually contains much more carbon than manganese, and that an appreciable quantity of manganese is lost by oxidation in alloying the molten components, this implies that, as the ferro-manganese usually contains at least 6 per cent. of carbon, it must contain at least $9 \times 6 = 54$ per cent., and better $13 \times 6 = 78$ per cent. of manganese.

In short, to avoid having in our steel more carbon than is desirable, we must use a ferro-manganese as rich as possible in manganese, and alloy it with iron containing as little carbon as possible.

Such iron is that made either in the Bessemer process or in the open-hearth process, by thoroughly decarburizing cast iron. In making merchantable steel (other than manganese steel) by either of these processes, a little carbon or manganese, or both, must actually be added to this thoroughly decarburized iron, in order to make it malleable, for reasons which we need not here consider. But in making manganese steel we deal with simply this thoroughly decarburized iron.

The loss of manganese in preparing manganese steel, according to Hadfield, equals about 0.50 per cent. of the total weight of the decarburized iron plus ferro-manganese used—*e.g.*, if the charge should by calculation, and without allowing for loss of manganese, contain 13.5 per cent. of manganese, it will actually contain about 13 per cent.

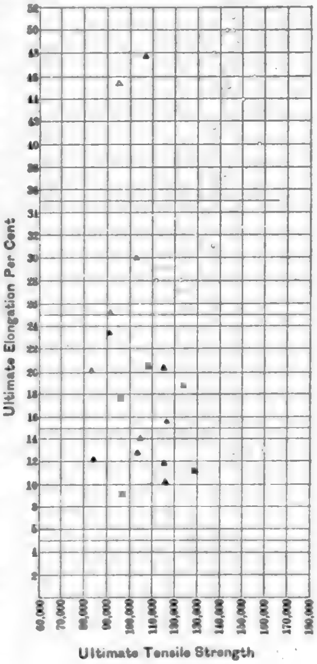


Fig. 7.

0 = Water-toughened manganese steel.
▲ = Rolled nickel steel.
△ = Rolled and annealed nickel steel.

TENSILE PROPERTIES OF MANGANESE STEEL AND NICKEL STEEL.

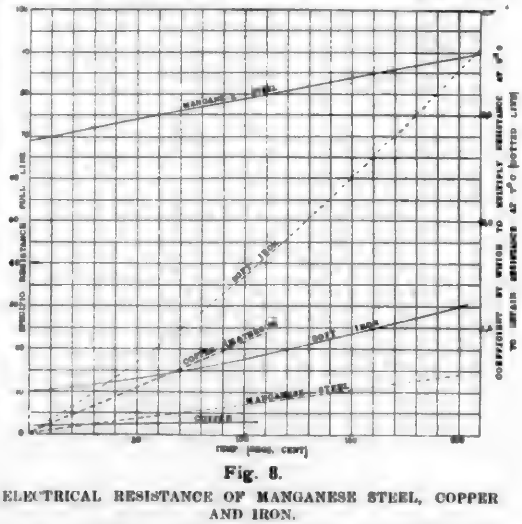


Fig. 8.

ELECTRICAL RESISTANCE OF MANGANESE STEEL, COPPER AND IRON.

After carefully mixing the molten iron and ferro-manganese, they are poured into suitable molds of iron or sand, as the case

may be. Large ingots are habitually cast in iron molds; and here an important precaution must be observed.

Thanks to the slowness with which this metal conducts heat, the outside of the ingot, in contact with the cold walls of the iron mold, cools so far as to be rigid and incompressible, while the interior of the ingot is still far above its melting-point. In cooling from this exalted temperature the molten, and later the solidified metal of the interior, undergoes great contraction, and no longer suffices to fill completely the outer shell of the ingot. Hence arises a deep vacuous cavity in its center, known as the "pipe." To meet this, the top of the ingot is covered with charcoal, so as to keep its upper surface molten, and fresh lots of molten manganese steel are from time to time added, in order to fill this cavity or pipe.

Treatment.—We now pass on to consider the treatment of manganese steel. In what may be termed its natural state—*i.e.*, when slowly cooled either from the initial heat of casting or after forging, *manganese steel is brittle.* The ductility which gives it value is obtained only by sudden cooling from a high temperature—*e.g.*, by plunging it while red-hot into cold water.

We are all familiar with the remarkable effect of suddenly cooling common steel, as, for instance, by plunging it while red-hot into water or oil; we all know how this hardens the metal, makes it relatively brittle, and, if judiciously performed, strengthens it. (In speaking of hardness, I invariably refer to the hardness proper, the resistance to indentation and abrasion.)

But the effects of sudden cooling on manganese steel and on carbon steel are in some respects very unlike. The tensile strength and elastic limit of both may, indeed, be greatly raised by sudden cooling; but even here a difference is noticeable. For while sudden cooling, even if very sudden, indeed violent, increases the strength of manganese steel greatly, the rate and conditions of cooling must, in case of carbon steel, be carefully regulated if great strength be sought; and indeed very sudden cooling may actually greatly weaken carbon steel, and require a subsequent tempering—that is to say, mitigating, or letting down.

When, however, we turn to the effects of sudden cooling on the hardness proper and the ductility of these two substances, carbon steel and manganese steel, we find a most marked difference. Sudden cooling hardens carbon steel greatly, and may make it so hard that it scratches glass readily; if it affects the hardness proper of manganese steel at all, its effect is so slight as to be detected only by delicate tests. Sudden cooling tends to lessen, and if very sudden may quite destroy the ductility of carbon steel, leaving the metal as incapable of receiving permanent set as glass is. Yet the same sudden cooling increases the ductility of manganese steel astonishingly.

Fig. 5 illustrates graphically the influence of sudden cooling on the ductility of manganese steel. Here the properties of manganese steel in its natural state are indicated by black semicircles, the circles indicating the properties of the metal when suddenly cooled by quenching in water, or, as it is called, "water toughened." We see that, while the elongation of the metal in its natural state is usually below 5 per cent., that of the water-toughened material rises occasionally to 50 per cent.

Fig. 6 illustrates in like manner the influence of sudden cooling or water-toughening on the tensile strength. We note that, while the tensile strength of the metal in its natural state, as indicated by the black semicircles, rarely rises above 100,000 lbs. per square inch, that of the water-toughened metal, indicated by the circles, is usually above 110,000 lbs., and rises to even above 150,000 lbs. per square inch.

(TO BE CONTINUED.)

CROSSINGS OF GREAT RIVERS.

A CONTRIBUTION TO RAILROAD LOCATION.

By A. Zdziarski, C.E.

APPENDIX.

THE HYDROMETRIC APPARATUS OF AMSLER.

As we have said in the chapter on the Measurement of Velocities,* the most suitable apparatus for measuring the velocities of current at different depths is the hydrometric apparatus of Amsler, or more exactly of J. Amsler-Laffon of Schaffhausen. We do not think that this apparatus is as well known among American engineers as it deserves, and we therefore present a detailed description of it.

The hydrometric apparatus of Amsler-Laffon consists of three distinct parts:

1. The mill, with a registering apparatus and the electric contact.
2. The electric signal, with its battery and conductors.
3. The winch, with weight for working at great depths.

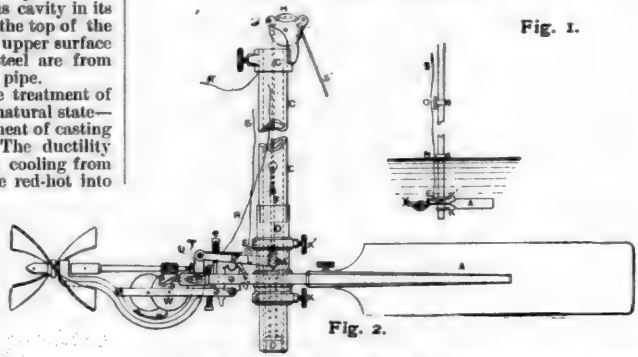


Fig. 1.

Fig. 2.

1. *The Mill.*—The mill consists of a pair of helicoidal blades (figs. 1 and 2) fixed on a horizontal shaft, and put in rotatory motion by the current of water. The shaft carries an endless screw, which by means of gearing communicates the motion to the registering apparatus, consisting of a divided wheel with an index. The wings, gearing and counter are fixed on a metallic frame, the opposite end of which carries a plane or conical rudder. The whole is supported by means of a vertical rod, a gas-pipe, or by means of steel wire stretched by a weight.

When the depth of water is not great the mill can be used in the same way as the other old hydrometric apparatus of Woltmann-Baumgarten, being drawn from the water in order to read the counter every time such reading is necessary. For this purpose the whole apparatus, with the plane rudder *A* (fig. 1), is put on a vertical rod and fastened by means of screws *K K'*. The lower end of the string *S*, serving to lock and unlock the register, is fixed to the eye *E* of a horizontal lever. Every time this string is quickly pulled the register is locked or unlocked. Of course before the apparatus is sunk the register must be unlocked and the position of index noted. When the apparatus is immersed, the counter is allowed to run for a definite time, say, from one to three minutes, which is done by pulling the string at the beginning and the end of this interval. The apparatus is then drawn from the water, and the number of revolutions of the blade is read on the register.

In greater depths this process is not certain enough, because when the apparatus is sunk to a great depth the current can stretch the string so that it will lock the register, and we can never be sure whether it is locked or unlocked. In order to avoid this, it is better to use, instead of a wooden rod, a ¾-in. gas-pipe *C*, screwed into a foot-piece *D* (fig. 2), to which the mill can be fixed by means of screws *K K'*, a cylindrical piece *c d*, and a round nut *d*. The string *S'* is now placed inside of the pipe *C*, and its lower end, provided with a carabin-hook, is passed through the eye *F* of the lever *L*. The string *S'* is put inside of the pipe *C* and connected with the lever *L* in the following manner: The pipe *C*, without the foot-piece *D*, is held in an inclined position, and the lower end of the string with the hook is put in the upper end of the pipe; then the hook, going before the string, pulls it down to the lower end of the pipe. The hook is then connected with the eye *F*, and the foot-piece *D* is screwed to the pipe *C*. To the upper end of the pipe a ring *G* with a pulley *H* is fixed, and the string *S'* passed over it.

The mill is now put on the foot-piece *D* and fastened by means of two screws *K, K'* in such manner that the points of the screws enter the conical holes drilled in the foot-piece. The locking lever *L* is connected with the string *S'* by means of a cross-pin *M*, which is driven through the holes of the lever and screwed. The counter is operated by pulling the string *S'* in the above described manner.

The ring *N* and the disk visor *O* (fig. 1) can be strengthened by screwing to the gas-pipe. The ring *N* marks the depth at which the velocity is measured, and it is so fixed that during the experiment it is at the surface of water. The disk visor

* See Railroad and Engineering Journal, September, 1892, p. 403.

O is fastened in such position that the plane of disk is at right angles to the shaft of the mill, and thus the disk indicates the direction of the mill under the water.

2. *The Electric Signal.*—The above-described manner of measuring the velocity of current is very tiresome, because the apparatus for reading the register must be frequently drawn from the water. In order to avoid these inconveniences, the apparatus with electric signal was devised.

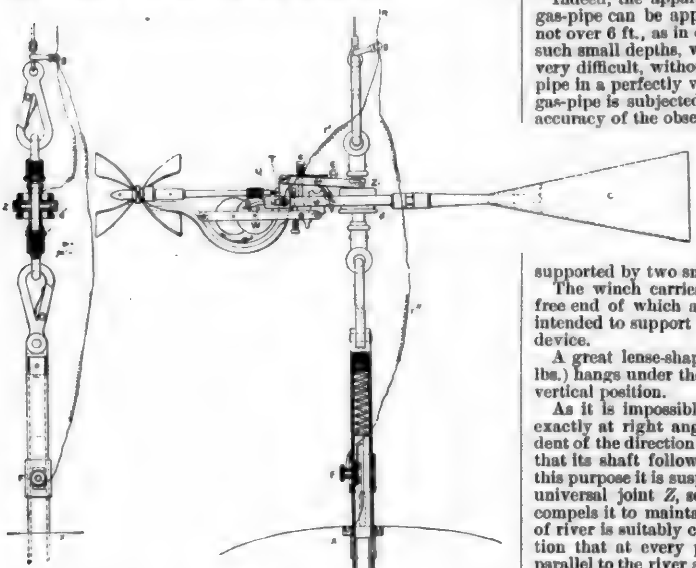


Fig. 3.

The electric signal consists of three distinct parts: (1) The electric contact P (fig. 2); (2) the box Q (figs. 4, 5, 6) containing an electric bell and a small galvanic battery of two cells; and (3) suitable conducting wires.

The electric contact P (fig. 2) consists of a metallic lever P, fixed to the frame of the apparatus, but insulated from it in T by means of an ivory ring and plate; and of a pin p belonging to the wheel W, and touching the lever P after every 100 revolutions of the blade.

The box Q (fig. 4) has two terminals a a'. One of them (a) is, by means of the insulated wire R (fig. 2) and the insulated pin U connected with the contact lever P; the other terminal a' by means of a small wire R', the gas-pipe, and the frame of the mill connects with the wheel W and the pin p. When the pin p touches the contact lever P the electric bell sounds, and the observer notes the time, preferably with a stop-watch.

Before sinking the apparatus in water, the register is locked and the worm on the shaft of the mill made to mesh with the toothed wheel W. Thus when the mill has made 100 revolutions, the electric contact P is locked and the bell sounds. It is to be noted that as the sounding of the bell lasts a certain length of time, it is advisable to note the end of the sounding, which is much more easily and exactly performed than to note its beginning. The interval of time between two observed ringings, say, T seconds, will correspond to 100 revolutions of the blades, and the number of revolutions in a second is

$$n = \frac{100}{T}.$$

The velocity of current is then calculated by the well-known formula

$$v = a + C\,n,$$

where a and C are constant coefficients to be determined from experiments in stagnant water. Every apparatus has its special coefficients, and even they vary with the time. As an example I quote the coefficients of two apparatus used in 1891 by engineers of the Western Siberian Railroads (in feet).

The apparatus No. 1

$$v = 0{,}091 + 0{,}8126\,n.$$

The apparatus No. 41.

$$v = 0{,}091 + 0{,}7602\,n.$$

3. *The Winch.*—The most important improvement made in this hydrometric apparatus, and which rendered them suitable for measuring the velocity of current at great depths, is the use of a winch and wire.

Indeed, the apparatus fixed on a wooden rod or even on a gas-pipe can be applied only when the depths are small, say, not over 6 ft., as in canals and small rivers; however, even at such small depths, when the velocity of current is great, it is very difficult, without special devices, to keep the rod or gas-pipe in a perfectly vertical position. Furthermore, the rod or gas-pipe is subjected to vibrations which militate against the accuracy of the observations.

The winch V (figs. 4, 5, 6) consists of a drum, which is put in motion by means of toothed wheel, pinion, and handle. The number of revolutions of drum is noted by means of a divided dial and pointer.

The winch is fixed at the bow of a small boat (figs. 4, 5, 6), or on a platform supported by two small boats side by side.

The winch carries a steel wire, ½ mm. in diameter, on the free end of which a carabin-hook is adjusted. This hook is intended to support the mill suspended by means of a special device.

A great lense-shaped cast-iron weight X (about 40 kil. = 88 lbs.) hangs under the apparatus and keeps the wire in a nearly vertical position.

As it is impossible to keep the mill suspended on a wire exactly at right angles to the cross-section of river, independent of the direction of water current, it is therefore so devised that its shaft follows this direction of current exactly. For this purpose it is suspended to the wire by means of the Cardan universal joint Z, so that the conical rudder C (figs. 3 and 5) compels it to maintain this position. When the cross-section of river is suitably chosen, the error arising from the supposition that at every point of the cross-section the current is parallel to the river axis and at right angles to the cross-section is very small.

As already stated, the mill is suspended to the wire by means of a special device, which consists of a joint piece Z, fixed to the ring-formed portion of the frame by means of a ring-shaped nut d (fig. 3). The upper end of this piece has an eye, which is caught by the carabin-hook of the suspension wire; the lower end has another eye for the carabin-hook of the weight.

The conductor R, connecting the terminal a of electric signal-box with the electric contact P, consists of an insulated wire R supported by means of an eye g (fig. 3) fixed to the lower end of the suspension wire. This suspension wire is at the same time the second conductor for the winch, and is connected with the other terminal a' of the electric signal. In g the conductor R divides into two conductors, one going to the lever P of the contact, and fixed in V to the mill; the other to the contact F, which is locked, when the lower projection of the weight touches the bottom.

During the observations made in the same cross section all these arrangements remain without change. The operation is still easier when the winch is located near the middle of the boat instead of on the bow, and the suspension wire is thrown over a pulley fixed at one end of the boat (fig. 5).

In order to measure the velocity of current at different depths of the same vertical line, the following mode of operating is followed: The weight is first sunk so slightly below the surface that the apparatus is at the level of water. The pointer of the winch dial (showing the length of unrolled wire) is then set at zero (this pointer holds by friction), the handle being stationary. Now, if by revolving the handle we unwind the wire and sink the apparatus to a certain depth, this depth is exactly indicated (in meters) on the dial of the winch. Before operating with the mill we measure the depth of the vertical. For this purpose we lower the weight to the bottom. The indication on the winch dial, increased by the distance from the shaft of mill to the bottom of weight attachment (0.5 meter), will give the exact depth of water on the vertical. The moment when the weight touches the bottom is signaled by a bell-ringing, which by its long duration differs from the periodical electric signal.

When the depth is exactly measured the observer divides them in suitable number of parts, and on depths corresponding to the points of division performs the measuring of velocity by noting the times corresponding to the periodical running of the electric bell.

A NEW METHOD OF SMELTING AND CASTING METALS.

Mr. George Ambrose Pogson, the British Vice-Consul at Hamburg, explained to a number of gentlemen at Sheffield lately the "Taussig" system of smelting and casting metals in exhausted chambers. The system is claimed to produce, by a single process, every 15 minutes, with an expenditure of 360 cwts. of coal per 1,000 cwts. of finished cast metal, bronze, iron, steel, copper, brass, zinc, platinum, gold or silver, free of pores or bubbles. The process is effected by electricity by means of metal electrodes (flat shaped) in an exhausted furnace, large molds being set up outside the furnace, and exhausted by one process simultaneously with exhaustion of furnace. Castings up to 30 lbs. of iron have been made in the presence of Her Majesty's representatives at Hamburg, within 15 minutes, the air pump in use showing 92 per cent. exhaustion of air, ampere gauge 2,500, voltage 2¼ volts. The electric current

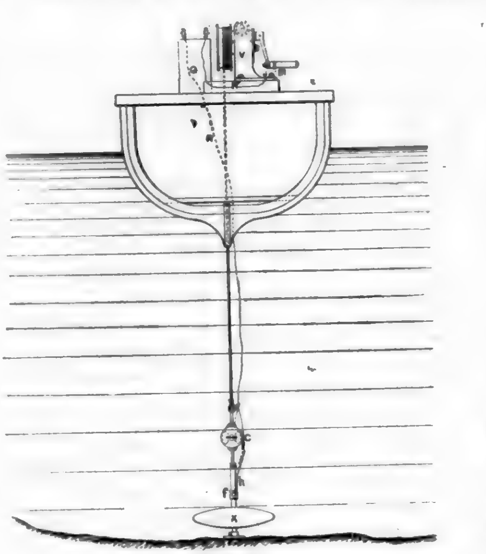


Fig. 4.

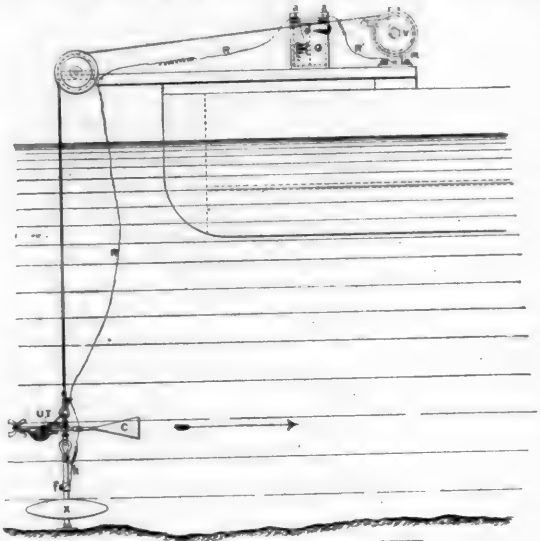


Fig. 5.

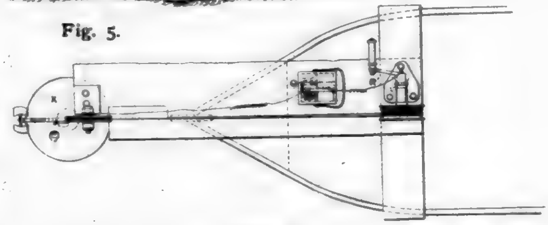
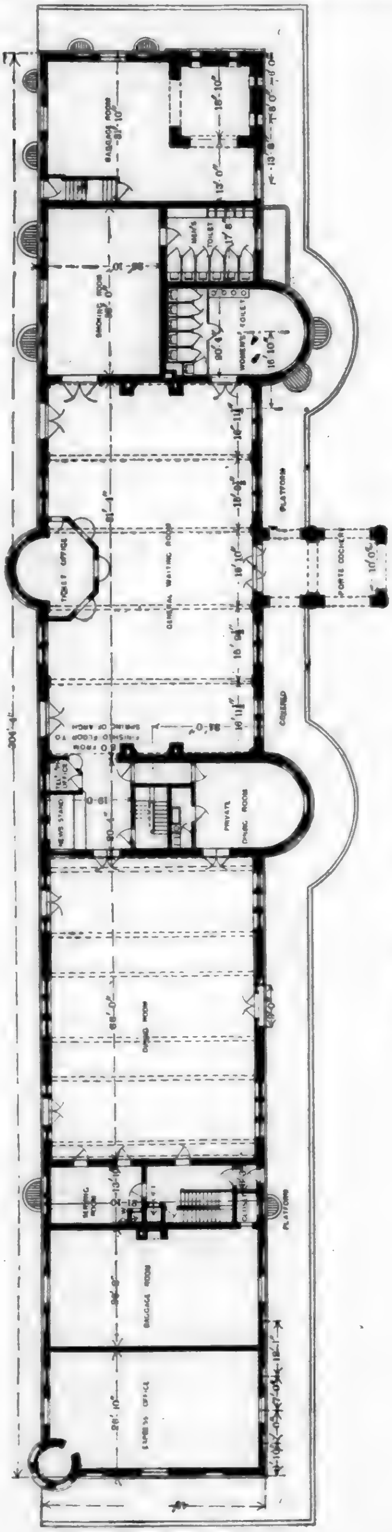


Fig. 6.

does not effect its work from outside through surface of crucible or furnace, but by conduction through the metal itself which is about to be smelted. Siemens-Martin steel is fused without other parts of the electric current undergoing any material increase of temperature. By use of metallic electrodes, all contamination of metal by carbon is absolutely avoided. As coal slack is not present in any large quantity, refuse is reduced to a minimum, and oxidization and creation of air bubbles are, it is contended, by this new method of smelting in a vacuum, by means of removal of carbonic acid gas, etc., also avoided. The metal becomes more liquefied and, on account of the casting forms being denuded of air, permits of extremely close and fine casting, even of objects of excessively small diameters. Among other pertinent justifications for these assumptions is the fact that the samples which have up to the present been tested in the proof rooms of the Royal Technical School at Charlottenburg, near Berlin, have, notwithstanding the prejudicial circumstances under which they have been produced, according to a copy of the Government report in regard to such tests, shown very satisfactory results. From the nature of the system adopted it ensues that the electric force which is carried out with currents of great strength, but low voltage, is attended with absolute freedom from danger. Small iron propellers and similar objects are constantly melted and cast at Bahrenfeld in the presence of witnesses within a period of 12 to 15 minutes. Currents of 20,000 to 30,000 amperes are no exaggeration, and exhaustion of air from the largest chambers now presents no difficulty. By the employment of 30,000 amperes and 50 volts, a force equivalent to about 2,000 H.P., or somewhat less than that used by the aluminium works at Neuhausen, on the Rhine, the casting form would have a minimum length of 12 meters, and a width of 1½ meters. This would give a body of metal of 180,000 cubic centimeters, or about 1½ tons. According to the experience gained in experiments at Bahrenfeld, such casting would be effected in one process lasting in all not longer than a quarter of an hour. The expenditure of coal is, therefore, in round figures but 50 per cent. of that necessitated by the most perfect system at present in use. The use of water power naturally increases these advantages in an enormous extent.

The iron furnace seen by Mr. Pogson at Professor Taussig's works at Bahrenfeld consisted of a rectangular vessel 6 ft. × 3 ft. × 3 ft. Two electrodes, apparently of wrought iron, were placed upright inside the furnace, so that their surface of 8 in. × 4 in. faced the arc-shaped piece of iron which was to be fused; a channel of clay served the purpose of conducting the fused metal from its clay melting bed into the empty clay mold of a model propeller, the mold in question being placed at a lower altitude in the otherwise empty iron furnace. The wires connecting the flat metal electrodes with the powerful generating machinery put up by Messrs. Schuchert & Company, the well-known German electrical engineers, were already in position, as was also the exhaust-pipe connecting the furnace with a steam air-pump of about 20 H.P., which also drove the dynamos. Having personally placed the 30 lbs. of pig iron in the clay bed, placed parallel with, but a few inches in front of, the flat electrodes, the cover of the oven was swung on; the necessary exclusion of external air being effected by India-rubber pads fastened to the furnace cover. Punctually at noon the cover was fastened down, and the pump set working, the current being switched on at the same moment. The indicator of the exhaust-pump soon showed an exhaustion of 92 per cent. of air. The electric indicators showed respectively 2,500 to 3,000 amperes and 2 to 2¼ volts. The gradual approach from red to white heat could be followed from the eyelets in the furnace. Fusion was obtained at about 12.8, the indicators showing great unsteadiness until the resistance had been reduced to *nil* by the current being allowed to pass freely through the fused metal. At 12.14 the furnace was opened, and a minute or two later the clay was being chipped off, and the perfect cast of a propeller was exposed to view.—*Sheffield Telegraph.*

Union Passenger Station, Portland, Me.



GROUND PLAN OF UNION PASSENGER STATION, AT PORTLAND, ME.

UNION PASSENGER STATION AT PORTLAND, ME.

We give herewith a full-page perspective illustration and a general ground plan of a new union station which has been recently built at Portland, Me., under the supervision of Messrs. Winslow & Wetherel, architects. The general appearance and arrangement will be readily understood from the examination of our engravings. The exterior is built of Conway pink granite, the roof being of light-green slates. The interior is richly and simply finished in hard wood. In the general waiting-room there are two handsomely carved stone fireplaces, which may be regarded as the principal feature of the interior. The building is heated by steam, lighted by electricity, and its details comprise every modern improvement and luxury known to the present time. We are indebted to the *American Architect and Builder* for the perspective and to the architects of the building for the plan.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 138.*)

In July, 1880, M. *Biot* exhibited to the French Society for Aerial Navigation an ingenious kite, invented by himself, which sailed without a tail and possessed great stability under all conditions of wind.

At the top of a flat plane of elongated elliptical shape two hollow cones were affixed, one on each side. The base or large end of these cones faced the wind, and the other end or point was slightly truncated, so as to leave an opening through which the wind could blow, and, by the action of the streams or columns of compressed air thus created, counteract any tendency of the plane to tip to one side or to the other. This provided for the lateral stability on the same principle as in the well-known Japanese kite, in which the side-pockets catch the wind and maintain the equipoise.

The fore and aft equilibrium was provided for by affixing a rotating screw at the lower end of the plane, pivoted on its central line. This screw had two vanes of coarse pitch, and was free to rotate under the impulse received from the wind. It spun around with great speed when the kite was raised, and obviated any need of the usual tail by performing the same steadying office. It prevented any oscillations, without impeding the rising of the kite, and maintained it perfectly steady in all winds.

It was not agreed between the French aviators whether this effect was due to the action of the vanes, making an angle with the sustaining plane, as in the case of *Pénaud's* "planophore," or to "gyroscopic" action, but when the screw was omitted the kite swayed about, while when the screw was rotating, its twirling and tremor could be felt through half a mile of string, and the kite remained perfectly upright and steady.

M. *Biot* carried on quite a series of experiments with this apparatus. In the kite which he used the elliptical plane was 15 in. high, the two cones at the side were each 8 in. in diameter at the base by a height of 8 in., while the screw was 12 in. in diameter, its two vanes being each 1⅝ in. broad.

The experiments were carried on in winds varying from 13 to 33 miles per hour, and the kite was found to be steady under all conditions, the only difference being in the height to which it would rise. When the wind blew from 13 to 18 miles per hour, 4,900 ft. of cord were paid out, the kite remaining at this distance during two hours. On other occasions, with stronger wind, as much as 6,500 and 8,200 lineal feet of cord were paid out, and the kite mounted so high that it passed through several strata or currents of wind of varying direction, as was conclusively proved by the fact that the restraining cord assumed a sinuous attitude when the full height was gained, and instead of approximating to a straight line or a regular curve, as usual, the line became serpentine in form, thus indicating that different trends existed in the various strata of air.

In one instance the kite, with 2,600 ft. of cord paid out, advanced against the wind and mounted directly over the head of the operator. This was attributed to an ascending trend in the wind, for the kite still tended to rise vertically and to advance against the wind, although the plane was

horizontal, and the cord, now greatly bowed by the wind, tended to drag the apparatus backward. This attitude continued but a short time, when, the trend of the wind having apparently changed, the kite settled back to its original position, flying at an angle of 40° to 60° with the horizon.

M. *Biot*, who was an old experimenter with kites (having as early as 1868 been lifted up from the ground by a large apparatus of this kind), found the gyroscopic stability of the arrangement which has just been described so satisfactory, that he thereupon designed, in connection with M. *Dandrieux*, a full-sized aeroplane on the same principle, calculated to carry up a man. This design was submitted early in 1881 to a special committee of the French Society for Aerial Navigation, but this committee seems to have hesitated in recommending its construction, and no record has been found by the writer of its having been built or experimented with about that time.

When, however, the publication and discussion of M. *Mouillard's* "L'Empire de l'Air" had directed fresh attention to the soaring of birds on rigid wings, and given grounds for the belief that man could utilize the wind in the same way, M. *Biot* constructed in 1887 a soaring apparatus in the shape of an artificial bird 27 ft. across, and weighing 55 lbs., with which he hoped to reproduce the manœuvres of the sailing birds.

It is known that a number of very interesting experiments were tried with this apparatus, but the writer has been quite unable to find in print, or to obtain from correspondents, a description of the machine or a record of its trials. He merely knows that these trials were many, and that on one occasion M. *Biot* suffered a tumble which was not encouraging to further experiment, but no account of them is to be found in the *Aéronaute*.

It is to be hoped that a full narrative may yet be given to the public of the results of experiments which must have been most instructive for other aviators who contemplate imitating the birds.

In 1882 M. *Jobert* exhibited before the French Society for Aerial Navigation the model of a proposed apparatus designed by himself, in order to test the possibility of imitating the manœuvres of the soaring birds, as described by M. *Mouillard*. This aeroplane was to be hinged and jointed, so that it might be folded up like an umbrella for convenience in transportation, or opened out and stiffened by sliding bars in order to make the wings rigid. With this M. *Jobert* proposed to experiment on various areas of surfaces in proportion to the weight, and to test the efficacy of both fixed and adjustable sustaining surfaces. He does not seem to have met sufficient encouragement to carry out his design, for the writer has been quite unable to learn that he ever completed a full-sized aeroplane capable of sustaining a man.

Having begun where M. *Biot* terminated—*i.e.*, with the design for a soaring apparatus—M. *Jobert* next turned his attention to kites, and proposed in 1887 the apparatus shown in fig. 67, which he termed a "rope-bearing kite," designed for establishing communication with wrecked vessels. It consisted of a hollow truncated cone *C*, under which was rigidly connected a kite *P*, from which depended two light lines terminating in a ring, the latter carrying a light cord steadied by the drag *D*. The object of this arrangement was to ensure a rapid and certain connection with the shipwrecked mariners, who, by seizing the light cord, could at once haul down the kite and thus gain access to the main carrying rope, with which to haul aboard the usual life-saving cable. This carrying rope was fastened to a bridle attached to the top cross-stick of the kite, and to the top of the cone at *V*, which arrangement was claimed to produce perfect stability, and to ensure that the apparatus should travel straight back in the line of the wind without rising to any great elevation. In order to regulate the height, the angle of the plane could be varied by means of a light string (not shown), extending from the lower cross-stick to the carrying rope and fastened by a hook in one of a series of loops.

The sustaining plane was, like the cone, formed of calico, in which hems were turned at the top and at the two sides, in order to form cases for the sticks of the frame, the lower edge of the kite being left uncased, in order to produce bagging and consequent increase of lifting power. At the small end of the cone a couple of thin metallic tongues were fastened, which, thrown into vibration by the wind rushing through the cone, produced a howling sound which might notify the shipwrecked sailors of the approach of the apparatus, and the whole arrangement, as will readily be perceived, was quite cheap and readily rigged up or folded away, no matter how large it might be.

The writer does not know whether this apparatus ever came into practical use. It has here been figured in order to show how a cone can be applied to a kite in order to impart stability to the latter, but the arrangement would need to be greatly modified in order to admit of its utilization in an aeroplane, so as not unduly to increase the resistance to forward motion.

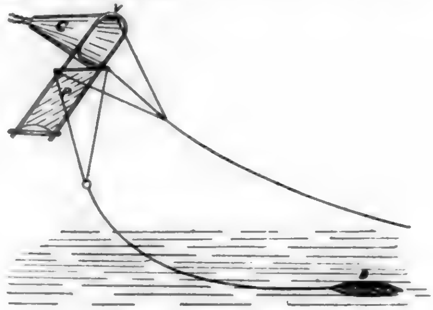


Fig. 67.—JOBERT—1887.

In 1886 and 1887 M. *Maillot*, a French rope-maker, tried quite a series of experiments with the kite represented in fig. 68. This was constructed of poles and canvas, in the shape of a regular octagon; it measured 775 sq. ft. in area, about 32 ft. across, and weighed 165 lbs. It had neither balancing head nor tail, and was so poised by the bridle of attachment that the center of pull corresponded to a point only one-third of the distance back from the front edge, or to a spot, therefore, decidedly forward of the center of pressure, at the comparatively coarse angles (30° to 60°) usually assumed by kites. This angle of incidence it was intended to regulate by a cord, attached to the rear edge and carried to the seat swung beneath the kite for the operator, who might then, by hauling in or paying out this cord, regulate the angle of incidence and cause the kite to rise or to fall. This was intended to furnish the longitudinal stability, while (there being no provision for automatic lateral equilibrium) the side oscillations caused by the varying intensity and directions of the wind were restrained by side ropes attached to the kite and handled by men standing on the ground.

In the first experiments (May, 1886) M. *Maillot* was dissuaded from ascending beneath the kite, and he therefore substituted for his person a bag of ballast weighing 150 lbs., tied just below the seat. The kite was raised by first securely anchoring the main rope, which was 800 ft. long, and then lifting up the front edge so that the wind might sweep under the surface, upon which the kite rose to such height that the bag of ballast swung some 30 ft. above the ground, where M. *Maillot* and two assistants managed the two side ropes and the tail cord (not shown in the figure), which latter regulated the angle of incidence by depressing or raising the rear of the kite.

Allowing 33 lbs. for half the weight of the main rope, it was estimated that the apparatus sustained, on this occasion, an aggregate weight of 348 lbs., or in the proportion of 2.23 sq. ft. per pound. The wind was variously estimated at 15 to 22 miles per hour; but as this speed was not measured, nor the pull upon the various ropes ascertained, while the angle of maximum incidence was merely guessed at as about 45°, no accurate computation can be made of the various reactions. The kite was easily controlled by the three men, hauling or paying out the two side ropes and the tail cord, but it plunged about with the varying intensity of the wind, and in one of the oscillations so produced the bag of ballast was whipped about and broke the rope by which it was suspended.

M. *Maillot* repeatedly experimented with this and other kites (but smaller) on the same principle during the year 1887. He states that he succeeded in sustaining as much as 594 lbs., but whether he ever went up himself beneath the kite the writer has been unable to ascertain. There would have been little or no risk in doing so, provided the wind was steady and strong, for it is evident that the three lines carried to the ground would give almost complete command over the apparatus, but then such a performance would have taught very little toward the management of an aeroplane free in the air. Changes were made from time to time in the modes and points of attachment of the various ropes, and the endeavor seems to have been directed to the discovery of some arrangement by which automatic equilibrium could be secured under all conditions and varying velocities of wind without the use of a tail. From the discontinuance of the experiments it is inferred that they did not succeed, and the writer attributes this failure (if failure it was) to the employment of a *single* rigid *plane;* for it will be remembered that M. *Pénaud* obtained a stable kite, on the principle of his "planophore," by adding to the upper pair of planes a second set, inclined at a slight angle to the first, the effect of which was to regulate the incidence.

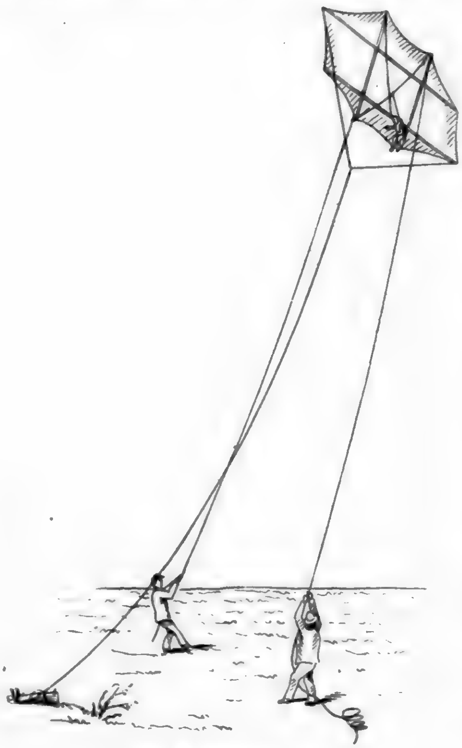


FIG. 68.—MAILLOT—1887.

On the same principle, M. *Barnett*, whose proposed aeroplane has already been noticed, obtained stability with a tailless kite many years ago, by shaping the plane like a laundry "flat-iron," cutting out a portion of this from the rear or broad end, and adjusting the band so obtained at an angle with the rest of the surface, so that the kite would fly steadily.

M. *Copie*, on the other hand, obtained partly the same effect by inserting a hemispherical pocket in the body of the kite, but this did not prove quite satisfactory until an opening was cut in the apex, on the same principle as the hole which is provided in the top of a parachute, after which the wind, rushing through the pocket, produced much the same effect as in the *Jobert* regulating cone; but the device is not one which can be profitably applied to an aeroplane in forward motion.

Upon the whole, M. *Maillot's* kite was rather crude, and decidedly inferior to *Pocock's* "charvolant," heretofore described, in which the pilot kite might be used to regulate the carrying kite. The stability of the *Maillot* arrangement could probably have been improved, and the side ropes dispensed with, by breaking up the surface into two planes, forming a diedral angle with each other, like the attitude of a bird gliding downward, or the same effect might have been partially produced by providing the plane with a keel.

Very good results with central keels have been obtained by M. *Boynton* with his various forms of "Fin" kites, which are now sold in the shops. They consist of a plane, to which is affixed at right angles a "fin" or keel located in the lower part of the kite, and raised slightly above its surface. They fly without a tail, with a steadiness depending somewhat upon the form of the main bearing surface, and seem to afford a good opportunity for further experiment as to the shape of greatest stability; for keels have been frequently proposed for aeroplanes, in which they will produce less resistance to forward motion than obtains with other arrangements, but few seem to have tested how such keels should be applied.

These remarks chiefly apply to *plane* rigid kites, and to the various adjuncts and forms which have been tried in order to confer stability upon a main plane surface sustaining the weight; but still better results have been obtained with flexible surfaces, and it seems not improbable that this is the arrangement which will give the greatest amount of stability to a kite, by producing automatic adjustment to the wind's varying intensity.

As an example of such action may be mentioned the "Bi-Polar" kite of M. *Bazin*, who experimented with it in 1888. It consists of a main sustaining surface like a boy's "bow" kite, or practically the same in shape as the kite surface in fig. 66. The frame is composed of two sticks, one of them a flexible rod at the head, bent to a bow, and the other a main central spine at right angles, to which the bow-strings are fastened. The peculiarity of the "Bi-Polar" kite is that this central spine is also made flexible, and that to its lower end (projecting some distance below the supporting surface of the kite) three triangular fins are attached, just like the tail of a dart, omitting one fin. This arrangement obviates any necessity for a tail and confers automatic stability, for the lateral equilibrium is obtained through the elasticity sideways of the main surface or head, which is blown back by the pressure to a convex surface with a diedral angle, which angle varies in accordance to the violence of the wind, while the longitudinal equipoise is likewise maintained by the balancing pressures on the head and on the fins, as the flexible spine yields more or less to the breeze. The kite is thus made stable in both directions, and flies steadily without a balancing tail. M. *Bazin* sailed it with two strings, one attached at the top and the other at the bottom of the main sustaining surface; these strings were both carried to the ground, and attached at each end of a stick of equal length with the vertical distance which they spanned at the kite, and with this stick in his hand the operator could vary the angle of incidence. This was intended to secure measurements of this angle of incidence in connection with the pull, but the results thus obtained have not as yet, to the writer's knowledge, been published.

Even better results can be attained with the "Malay" kite, which is in shape a lozenge, composed of two flexible sticks crossing each other at right angles. The cross or horizontal stick is the longest, being preferably 1.14 times the length of the upright stick, and fastened to the latter at a point 0.18 of its length below the top; a string is then carried (in notches at the ends of the sticks) around the periphery of the resulting lozenge, and this is covered with paper or with muslin in the usual way. This surface, when impinged upon by the wind and restrained by the bridle, is bent back by the pressure and adjusts itself to the varying irregularities of the breeze, the kite flying without a tail with great steadiness and rising to great elevations.

M. *Eddy*, of Bayonne, N. J., who has been constantly experimenting with kites during the last few years, and who is recognized as an expert in such matters, prefers the "Malay" kite to all others. He has improved it by so fastening the cross-stick and tying its outer ends as to

produce a slight initial convexity, which is further increased by the action of the wind, and which materially adds to the steadiness of the flight. With this arrangement M. *Eddy* has succeeded in causing a single kite to ascend to a height of 2,400 ft. with 3,000 ft. of line, and then bringing it to the zenith directly over his head, or even a little back of his hand, where its attitude strongly suggested the advance of the soaring bird against the wind. Upon a previous occasion he had succeeded in attaining a height of 4,000 ft., with a string of five kites flying in "tandem"—that is to say, each kite attached by a string of its own to the string of the preceding kite already raised, so as to take up the slack or sagging of the line, and thus enable the upper kite to rise to an altitude otherwise unattainable. This performance seems to suggest an easy way for the exploration of the upper air by the Weather Bureau, for by affixing to the upper kite self-registering instruments (thermometer, barometer, hygrometer, etc.), or, preferably, by connecting such instruments (and an anemometer besides) electrically with recording instruments on the ground (through a series of fine wires insulated in the kite string), observations of the conditions prevailing aloft can be easily obtained. The French have lately been making such observations by means of "free balloons" of medium size, and they are said to be of material assistance in forecasting the weather; the records obtained from the top of the Eiffel Tower showing that even at that moderate height coming changes in wind and in temperature are indicated several hours in advance of their prevalence at the ground.

The same principle of obtaining stability without a tail, by means of an elastic frame, can be applied to other forms than the "Malay" or the "Bi-Polar" kites, but it requires a good deal of delicate adjustment and balancing. It has been done with the common octagonal form of kite by M. *C. E. Myers*, of Frankfort, N. Y., the aeronautical engineer who furnished and operated the balloons and kites by means of which the recent (1891) rain-compelling experiments were tried in Texas.

It will be remembered that the explosions intended to produce rain were in some cases produced by exploding dynamite suspended below kites, and fired by electricity. In providing for this, M. *Myers*, who has for several years been conducting systematic experiments with kites, evolved some very interesting facts, and he has published part of his experience in the *Scientific American Supplement* (No. 835) for January 2, 1892, from which the following is extracted:

The originating cause of my interest in kite-flying is aerial navigation, and by successive steps I have adapted kites to fly without tails, to fly with considerable weight attached, and, finally, to fly without the restraint of the usual kite-string; and, rising higher and higher, finally to disappear miles in height and miles away on the verge of the distant horizon.

Theoretically, there should be no difficulty in attaining these results. Practically, there is as much difficulty as with a child learning to walk or a youth learning to manage a bicycle. In a word, it is the art of balancing. . . .

Theoretically, the kite should be light or possess much surface with little comparative weight. It should balance at the flattest possible angle, nearly horizontal, and its surface should be widespread, like the wings of a soaring bird. As a fact, I have obtained the best results with this model, but had great difficulty at first to induce it to fly at all, and was finally forced to attach a compromise tail—not a kite tail, but a bird-like tail, which, being flexible, vibrated or undulated with the vertical oscillations of the kite, and thus acted as a propeller, so that this kite actually moved against the wind. . . .

The most practical form of kite for general purposes seems, however, to be the six-sided. Those created by me as part of my apparatus for the Government rainfall expedition in Texas were composed of an X, formed of two spruce sticks, each 6 ft. long, tapering, with a top section of ¼ in. × ¼ in. and bottom section of ½ in. × ½ in. tacked flatwise together with a very small pin-nail, and bound with hemp cord at the joining. Five in. below this crossing (which was about 2 ft. from the top) was a similar piece of timber, but 14 in. shorter, and tapering each way, placed crosswise of the X, horizontally, so as to form a 5-in. triangle, which stiffened the frame more than if all crossed at one point. The outer end of each stick was creased with a knife and notched around, so that a hemp cord passed first through the crease and was "half-hitched" around each stick to prevent splitting. The kites were covered with red calico, pasted on tight, and bits of cloth were also pasted across the sticks where the kite-strings attached. These strings were attached as long loops—one loop to the top sticks about 6 in. from their tips, one loop to the two bottom sticks about 30 in. from the bottom, and one loop to the cross-bar about a foot from each end. All these loops were then gathered together and drawn through one hand as the kite lay on the ground, held in place by one foot on its crossing, and being adjusted carefully and equally to draw from *a point somewhere midway between the cross-stick and top*, best attained by trial, were then tied together.

The kite was thus rather stiff and light at top, *elastic* and heavier at the bottom, and suspended at a point *above* its center of gravity and center of surface. To the loop at the bottom was usually hung a narrow strip of cloth to afford greater steadiness in supporting the kite's burden of dynamite to be exploded. I have been thus particular to describe minutely this construction because many have written me for this information.

The first trial kite flown at Midland, Tex., escaped. I had built it all myself, as a model, and it had drawn up one ball of hemp twine, and an assistant was holding the string preparatory to running out another ball when the cord parted at a flaw, and the kite flew into space. When last seen with a glass, it was estimated to be about 3 miles high and 8 or 10 miles away, a fading red dot in the distance. . . .

In ordinary light winds this kite floats well, is steadier than many other kinds I have tried, and would seem to be well adapted for photography. If hung very near its top, it is prone to advance upward and forward against the wind, till over and beyond the party holding the string, and literally floats on the air as if propelled by its fluttering triangular section at or near the bottom of the kite.

The accidental escape of this kite exhibited a very interesting example of partial "aspiration," and it is understood from additional information, kindly furnished by M. *Myers*, that he succeeded in reproducing this effect on several occasions. The kites were hung, after considerable experiment, so that they floated nearly flat on the air, with as little tail as possible, and sometimes none at all. They rose upon a light breeze, and drew away as long as the string was let out. When checked or pulled, they rose higher and higher until quite overhead, when the string had to be released. If suitably balanced the kite then rose still higher and drifted back, *but not as fast as the wind blew*, its rearward flap vibrating more or less, and *making its action a progressive one relative to the wind*, thus producing "aspiration" with respect to the breeze. A long string, or small weight at the end of a shorter string, was sufficient to keep it balanced, so that it might remain up for hours and go floating out of sight.

The possibility of this progressive action against the wind without loss of height or of "aspiration" has been strenuously denied, and yet it is easily explained if, instead of assuming the wind to blow horizontally, as we generally do, we consider that it has at times a more or less ascending trend, this being a not unusual condition over the sun-broiled plains of Texas. It is clear, from the description of the mode of attachment of the string, that its weight when released would tilt the kite forward, so that the plane would point below instead of above the horizon. In this position the direction in which the "drift" is exerted would be reversed—that is to say, the horizontal component of the pressure, instead of pushing backward, would be pulling forward, and thus *become a propelling force against the wind*, provided, of course, that the latter still exerted its pressure on the *under side* of the kite. Thus an upward trend in the breeze of but 3° or 5°, operating against a kite inclined forward 2° below the horizon, would be sufficient to cause it to advance relatively to the wind, somewhat as a vessel "close hauled" advances against the breeze which furnishes it motive power. In point of fact, therefore, that which has herein been termed the "drift" may act upon a *plane* surface, as a force pushing backward or propelling forward, according as that *plane* is inclined to the front *above or below the horizon*; but in the latter case there needs be an ascending trend in the wind in order to produce a sustaining pressure on the under side, for otherwise the horizontal wind would strike the upper surface of the *plane* and press it downward instead of upward. The effect may be quite otherwise with concavo-convex surfaces.

(TO BE CONTINUED.)

RESISTANCE OF METALS TO SHEAR.*

By H. V. Loss, M.E.

(*Continued from page 182.*)

APPENDIX.

In reviewing the results of the experiments, we find that in some instances new facts are developed; in others, that the present ideas are corroborated and their details specified, while again in some cases the results appear to contradict hitherto prevailing assertions.

In regard to this latter fact, a few words may be said in explanation.

John W. Nystrom gives, in his "Pocket-Book of Mechanics," a formula for the necessary power to cut any iron bar of a thickness t—given in number of sixteenths of an inch—with a knife of a given bevel, a:

$$P = O.88\, t^2 \cot. a.$$

That this is erroneous will easily be seen when assuming $a = O$, in which case $P = \infty$. Besides, the formula does not contain the width of bar, which element, as seen from plate No. 6, will always make itself felt up to a certain limit, depending upon t and a.

Clark gives in his "Manual," on page 587, some results of experiments on iron bars with flat knives. The width was 3 in. and the thicknesses were ½ in. and 1 in. The resulting figures show a small difference in ultimate pressure per square inch for the two thicknesses, or, in other words, the maximum resistance per inch of width was not in proportion to the thickness of the bar—a result which is not confirmed by plate No. 10. However, the experiments were so few and limited—being only made with one width of bar and two thicknesses—that they would form but a meager guide as to any general doctrine that may be said to govern the shearing of metals.

In order to throw some additional light upon this subject, the writer devoted some little time to such experiments and analysis that would explain the action of the shear blades during their penetration of the bar.

It is not the idea of the writer at the present time to give an exhaustive theoretical analysis of the subject, but rather to indicate the lines upon which such an analysis can be made, and to emphasize the fact that the theory of flexure is mainly if not solely the correct theory of shear as existing with practical shearing machinery.

The following calculations were made with this in view, and as an example the shearing power for rectangular bars has been deduced with flat knives. The writer has likewise computed some of the data and elements necessary for the analysis of shear with inclined knives, all based upon the application of the theory of flexure.

If practical shearing means flexure, why does the ultimate resistance, when using flat knives, simply depend upon the thickness of bar in 1th power?

Some experiments were made with the view of finding the leverage of pressure existing at the point of maximum resistance, or at a period when the hydraulic force P was of a known quantity. They were conducted on soft steel, and the progress of knives was arrested either by stalling the hydraulic ram or by reversing the valve lever immediately the first "break" occurred. A beveled knife—8°—was used, as with a flat knife the point of maximum resistance is too close to the point of final rupture to allow the stoppage of the blades, if accomplished by the lever, to take place with any accuracy. The mark left on the top surface of the bar, as having been in contact with the underside of top knife, was precisely and invariably a duplicate of the one left on the under side of the bar, as having been in contact with the top side of the bottom knife. These marks were of a triangular form, and the table, No. 7, gives the values of the letters on fig. 3 as found from the experiments with the different sizes.

TABLE NO. 7.

w	t	r	s_1	Remarks.
5"	1⅛"	4⅝"	⅝"	Broke.
6"	1⅜"	4⅜"	13/16"	Broke.
6"	2⅛"	3½"	1⅛"	Stalled.
7"	2"	4⅜"	1 1/16"	Stalled.

* The articles in this series which have preceded this have all been copyrighted; the note to that effect was, through an oversight, omitted.

The two last bars on the table did not break, the knives being stalled at a total pressure of 330,000 lbs.

Comparing the values of s_1 and t, we observe a close relationship to exist between these two dimensions; thus we find:

TABLE NO. 8.

$w =$	5"	6"	6"	7"
$s_1 =$	.55 t	.59 t	.55 t	.53 t

As an average result we have

$$s_1 = .55\, t. \tag{4}$$

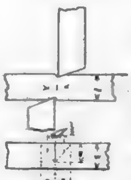


FIG. 3

The total shearing power P is distributed on the triangular surface, the dimensions of which are r and s_1.

With a view of determining this distribution in order to find the position of the center of pressure, let d_1, fig. 4, represent the depth of cut or compression at the edge relating to the dimension r and s_1.

At a distance s, the differential area of bearing surface is

$$\delta\,\Delta = r\left(\delta\, s - \frac{1}{s_1}\, s\, \delta\, s\right) \tag{a}$$

If p_1 = pressure per square inch of surface at the edge, corresponding to the distortion d_1, let p represent the pressure at d. We have:

$$p : p_1 = s_1 - s : s_1, \text{ or}$$

$$p = p_1\left(1 - \frac{s}{s_1}\right) \tag{b}$$

But this pressure, p, reaches the intensity as expressed by equation (b) only at the edge, decreasing directly with the distance inward, and finally becoming zero. Its average value on the differential surface is

$$\tfrac{1}{2}\, p_1 \left(1 - \frac{s}{s_1}\right)$$

Multiplying this expression by equation (a), and integrating between S_1 and O, the result will equal P. Thus

$$P = \int_O^{s_1} \tfrac{1}{2}\, p_1\left(1 - \frac{s}{s_1}\right) r\, \delta\, s \left(1 - \frac{s}{s_1}\right) = \tfrac{1}{2}\, p_1\, r \int_s^{s_1}\left[\delta\, s - \frac{2}{s_1}\, s\, \delta\, s + \frac{1}{s_1^{\,2}}\, s^2\, \delta\, s\right]$$

$$= \tfrac{1}{2}\, p_1\, r\left[s_1 - \frac{2}{s_1}\,\frac{s_1^{\,2}}{2} + \frac{1}{s_1^{\,2}}\,\frac{s_1^{\,3}}{3}\right] = \tfrac{1}{2}\, p_1\, r\, \tfrac{1}{3}\, s_1$$

$$P = \tfrac{1}{6}\, p_1\, r\, s_1, \text{ or}$$

$$p_1 = \frac{6\, P}{r\, s_1} \tag{5}$$

Inserting (5) in equation (b) we have

$$p = \frac{6\, P}{r\, s_1}\left(1 - \frac{s}{s_1}\right) \tag{c}$$

In order to find the moment of the pressure on the surface $\delta\,\Delta$ about the line $X - X$, we have

$$\delta\, Mm = \tfrac{1}{2}\, p.\ \delta\,\Delta.\ s = \frac{3\, P}{r\, s_1}\left(1 - \frac{s}{s_1}\right) r\, \delta\, s\left(1 - \frac{s}{s_1}\right) s$$

$$\delta\, Mm = \frac{3\, P}{s_1}\left(1 - \frac{s}{s_1}\right)^2 s\, \delta\, s, \text{ and}$$

$$Mm = \frac{3\, P}{s_1}\int_O^{s_1}\left(1 - \frac{s}{s_1}\right)^2 s\, \delta\, s = \frac{3\, P}{s_1}\int_O^{s_1}\left[s\, \delta\, s - \frac{2}{s_1}\, s^2\, \delta\, s + \frac{1}{s_1^{\,2}}\, s^3\, \delta\, s\right]$$

$$= \frac{3\, P}{s_1}\left[\frac{s_1^{\,2}}{2} - \frac{2}{s_1}\,\frac{s_1^{\,3}}{3} + \frac{1}{s_1^{\,2}}\,\frac{s_1^{\,4}}{4}\right] = \frac{3\, P}{s_1}\,\frac{s_1^{\,2}}{12}$$

$$Mm = \tfrac{1}{4}\, P\, s_1 \tag{6}$$

The distance from the center of pressure to line $X - X$ is now

$$\frac{l}{2} = \frac{Mm}{P} = \frac{\frac{1}{4}\, P\, s_1}{P} = \tfrac{1}{4}\, s_1$$

The total leverage with which the force P causes a moment of flexure is now

$$l = \tfrac{1}{2} s_1 = \tfrac{1}{2}\,\tfrac{5}{8}\, t = \tfrac{5}{16}\, t \qquad (d)$$

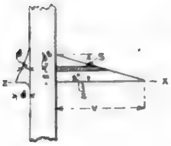


FIG. 4

We can assume the same leverage to exist with flat knives, in which case the triangle of bearing surface becomes a rectangle. This assumption is in accordance with the idea of a flat knife having a bevel, a, the value of which is infinite small, in which case the angle between the hypotheneuse in the triangle and line $X - X$ becomes infinite small as well, or practically speaking, zero.

In this case, we have for the bending moment

$$Mm = P\, \tfrac{5}{16}\, t = w \frac{t^2}{6}\, f,$$

where f denotes the tensile strength of the material. Continuing,

$$P = \frac{18}{5 \times 6}\, \frac{w\, t^2}{t}\, f = \tfrac{3}{5}\, w\, t\, f = \tfrac{3}{5}\, A\, f \qquad (7)$$

Thus we see that while bending really *does* occur, the thickness of bar, nevertheless, exists only in 1[th] power. Considering the cross-area of the bar A, we find the ultimate shearing power to be the product of this area and three-fifths of its tensile strength. Equation (7) gives the theoretical explanation why only a certain fraction of the tensile resistance is "the apparent coefficient of strength" of a bar when exposed to shearing. The writer fully believes that this is a feature rarely understood.

The general opinion is undoubtedly that all square inches do equal work, but that each one possesses a strength or resistance which represents only a certain percentage of the tensile strength of the material. To be sure, there is a direct shear as well, but this stress is under 90° with the former, and the bar will break before the latter has reached its ultimate.

Comparing equation (7) with plate No. (10), we have for a bar 1" wide × $1\frac{1}{16}$" thick, the result by diagram to be 50,000 lbs.

Equation (7) gives for the same dimensions, when considering 75,000 lbs. steel,

$$P = \tfrac{3}{5}\; 1.0625\; 75000 = 48000 \text{ lbs.}$$

In examining plate No. (12), giving the ultimate pressures for angles, it is clearly seen that the thickness of leg t enters any possible equation for P in a power less than 1. Assuming a parabolic expression:

$$P_1 = K \sqrt{t} \qquad (e)$$

Plate (12) is satisfied by having $K = 38000$, or

$$P_1 = 38000\, \sqrt{t} \qquad (f)$$

or for the total width of angle its legs being a and b.

$$P = 38000\, (a + b) \sqrt{t} \qquad (8)$$

Comparing equations (7) and (8), it may be possible to derive from the former expression a general formula for angles, based upon the principles used in the analyses in equation (7). With the form of die here used, t will become $\sqrt{2}\, t$, while the total width is diminished in the same ratio. Assuming the new thickness in the power of $\frac{1}{2}$, and inserting $\frac{a+b}{\sqrt{2}}$ instead of w, we have

$$P = \tfrac{3}{5} f \frac{a+b}{\sqrt{2}} \left(\sqrt{2}\, t\right)^{\frac{1}{2}} = \tfrac{3}{5} f \frac{a+b}{\sqrt{2}} \sqrt{t} = \tfrac{4}{9} f\, (a+b) \sqrt{t} \qquad (9)$$

If the above assumptions are correct, then

$$\tfrac{4}{9}\, f = 38000, \text{ or}$$
$$f = \tfrac{9}{4}\; 38000 = 85000 \text{ lbs. per square inch,}$$

as the ultimate tensile strength of the steel. This figure corresponds fairly well with the ultimate mentioned for steel angles, running up to 80,000 lbs.

When applying formula (9) to iron angles, inserting $f = 50000$, the results will invariably be too small. A value of $f = 65,000$ will give the desired results with fair accuracy. This is in harmony with the statement made in the earlier part of this paper, that the ratio between the shearing ultimates of iron and steel is not the same as the one acquired by tension in the testing machine.

Does this mean that with iron, and slightly also with steel, the coefficient of *ultimate transverse* strength is quite different from the coefficient of *ultimate tensile* strength?

With inclined knives the most intense pressure exists on the fibers at the edge first touched by the knife. The first break also occurs here.

Equation (5) gives an idea of the great numerical value of the stress at this point. The product of r and s_1 becomes so small for light bars as to cause a rate of pressure at this edge far above P itself.

The width of bar will enter any expression for the ultimate shearing resistance when using inclined knives. Plate No. 6 shows this fact most clearly. But this same plate also indicates the limit, where w disappears. Judging from the two thicknesses there shown, it would appear that a parabolic equation would express the limiting value of w with fair exactness, or

$$w = \sqrt{p\, t} \qquad (g)$$

Insert here $t = 1\frac{1}{8}$" and assume $w = 7$", being practically the limit, as shown on diagram, we find

$$p = \frac{w^2}{t} = \frac{49}{1\frac{1}{8}} = 43.5, \text{ and}$$

$$w = \sqrt{43.5\, t} = 6.6\, \sqrt{t} \qquad (10)$$

With $t = 1\frac{3}{4}$", we find $w = 8\frac{3}{4}$", which agrees very well with the experimental results, as shown on plate No. 6.

When examining plate No. (11) we find the experimental records of the energy necessary to shear rectangular steel bars with flat knives to correspond very closely to the conic expression:

$$E = 1100\, w\, t^2, \qquad (11)$$

E being the energy required in foot pounds.

This same equation can also be applied to steel angles, when remembering that the form of die used changes t into $\sqrt{2}\, t$. Denoting the length of legs by a and b, we have

$$E = 1100 \left(\frac{a+b}{\sqrt{2}}\right) \left(\sqrt{2}\, t\right)^2 = 1600\, (a+b)\, t^2. \qquad (12)$$

In letting the results of his work go to the press, the writer trusts that they will alleviate a long felt want on the question of strength of materials. If the analysis is not at present quite as complete as desired, the writer hopes to have an opportunity at an early date to finish it more elaborately.

It is a question, at any rate, if the practical engineer and designer, to whom this work is especially dedicated, does not, after all, prefer the graphical and more illustrative results to a rather complex mathematical analysis.

It may be argued that the experimental range of this paper does not include bars of very small dimensions, nor does it include round bars. The writer will reply to such a criticism that round bars are generally very small bars, and small bars are omitted, because nearly all shearing machinery is designed for large dimensions, or such as come inside the scope of this paper.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

The following is a list of accidents which occurred during the month of March to the class of railroad employés named above. As mentioned in the last number of our JOURNAL, the purpose of this publication is to make known the terrible sacrifice of life and limb among this class of people, with the hope that it will indicate some of the causes of accidents of this kind and help to lessen the awful amount of suffering due directly and indirectly to them. We will be much obliged for any information from any source which will help us to make our list as complete and correct as possible, and which will indicate the causes or the cures for any kind of accidents which occur. The following list includes the accidents which occurred during the month of March of which we have been able to obtain information. Doubtless others have occurred of which we have no knowledge:

ACCIDENTS IN MARCH.

Wilkesbarre, Pa., March 3.—Engine No. 494 on the Lehigh Valley Railroad exploded her boiler near McKune's Station, 15 miles north of Pittston, this morning, killing William Brown, a pilot, who had been sent to assist the train over the Buffalo division, and fatally injuring Charles Sincebaugh, the en-

gineer; Perry Refenburg, the fireman, and John Schott, a brakeman. The force of the explosion carried the boiler off the frame, and what remained of the engine held the track and ran as far as Falls Station, where it came to a standstill on an up grade.

The engine, it is said, was a "dirt burner," but of what particular type is not stated.

Chester, Pa., March 4.—The "Washington flyer" on the Lehigh & Hudson River Railroad crashed into a freight train near Buttsville, N. J., yesterday afternoon. Fireman Cullen was seriously if not fatally injured.

Richmond, Ind., March 4.—A collision occurred two miles west of this city. A construction train was going west, and came in collision with an east-bound freight. The latter had the right of way, and the order required the work train going west to side-track for the freight, which was overlooked. The trains came together while rounding a curve. When the east-bound train first rounded it, it was moving at a speed of 15 miles an hour, while the work train was going at a much greater speed. Both engineers saw the danger and reversed their engines, but the collision could not be avoided, and the trains came together with a crash. Following is a list of injured: C. M. Jennings, Indianapolis, brakeman, head cut and bruised; Daniel Lyons, fireman, Indianapolis, side hurt, internal injuries; Bernard Leonard, brakeman, head cut, side and shoulder injured; William Lock, brakeman, Cambridge City, leg injured. The engines were smashed and several cars derailed.

Buffalo, N. Y., March 4.—While Engine No. 692 was drawing the New York State Express, when about three miles east of Crittenden, the pin holding in place the side-rod on the right side of the engine broke. It crushed through the cab, paring it off as smoothly as a knife would have done. Fireman Marle was severely injured internally. His arm was also crushed, his back strained and his face considerably bruised.

About half an hour later another accident occurred which was almost identical. This likewise happened a few miles west of Batavia. A west-bound freight train was traveling rapidly when the rod connecting the driving-wheels of the engine broke. There was a general smash as a result. Two of the wheels were separated from the engine and the others were badly damaged. The engine is a complete wreck. No one was injured.

Cincinnati, O., March 5.—Three men were fatally injured in a smash-up in the Little Miami Yards, on Eastern Avenue, this morning. A number of freight cars were standing on the tracks and through a misplaced switch two yard engines crashed into them. The engineer jumped and escaped serious injury. Fireman Joseph Lee received injuries which will result in his death. Brakeman Charles Walker and Patrick Donnelly were also fatally injured.

Hagerstown, Md., March 5.—The boiler of a freight locomotive exploded about nine o'clock in the evening while drawing a heavy train on the Western Maryland Railroad at East Hagerstown Station. The engine had just passed the station when the accident occurred. H. Hawk, fireman, was blown from the cab to the top of a shed about 30 ft. away. The clothes were torn from him and he was blistered from chin to hips. One arm was broken. Mr. Hawk will probably die.

The engineman, George P. Smith, was blown from the locomotive by the force of the steam and one of his legs was broken. He was also badly cut. Brakeman Thomas Lefevre, also of Hagerstown, who was on the locomotive, was thrown from it. His back was severely hurt and he was scalded.

The train was going down-grade at the time, as said, and without engineman, fireman or front brakeman, drifted along to Antietam, two and one-half miles distant, where the up-grade begins and where the train stopped. The rear brakeman, who knew nothing of the accident, hurried forward and discovered the peculiar and serious state of affairs. Trainmaster Shreiner was informed of the occurrence, started with a yard locomotive to investigate, picked up the injured men and cautiously followed the train, catching it at Antietam. None of the men can tell how the accident occurred. The engineman says he had the injector at work and the steam cut off, and that the train was drifting along. It is said the boards in the front of the tender looked as if riddled with shot, so fiercely had the vapor driven pieces of coal into them.

Punxatawney, Pa., March 6.—Arthur Jones, a fireman on a locomotive, was badly burned on Monday night by the bursting of a pipe.

Stevens Point, Wis., March 6.—The right side-rod on engine No. 23, on the Wisconsin Central Railroad, broke and severely injured Engineer J. H. Hollman in the back and hips. The accident occurred two and one-half miles west of Stanley while making a curve, and the train being at a low rate of speed little damage was done, aside from the injury of its engineer. No serious results are anticipated as the result of his injuries. The accident was similar to one which occurred a couple of weeks earlier, in which Engineer McMillan got a severe shaking up.

Stevens Point, Wis., March 7.—A passenger train met a local freight in a head-end collision at Hewitt, on the Wisconsin Central Railroad. Three crews jumped and left their engines, as one locomotive crashed into another. Two were slightly injured in this wreck. A. P. McMillan, engineer of the passenger train, received a bruise in the face, disfiguring his nose; and Fireman Harry Spaulding sprained his ankle in jumping out of the cab window to the ground. The accident was attributed to the absence of a light at a switch which was open.

On the 9th an express engine on this same road "lost a driving-wheel tire," but no one was injured.

Quakertown, Pa., March 9.—Passenger train No. 328 on the north branch of the Reading Railroad ran into a landslide near Bingen last evening. Engineer Alfred Degrant was killed and his fireman badly hurt. The baggage-master was slightly injured. The passengers were badly shaken up, but no passenger was injured. The engine and three cars were wrecked.

Deckertown, N. J., March 9.—The Boston Express, on the Lehigh & Hudson River Railroad, ran into the rear end of a freight train, demolishing the engine of the express, wrecking the caboose of the freight and severely injuring the fireman of the express.

Petersburg, Va., March 11.—A collision occurred on the Atlantic Coast Line at Weldon, N. C., caused by a vestibule express train, north bound, running into the caboose car of a freight train which was standing on the main track. The occupants of the caboose were Conductor Edmund Gee, of Petersburg, and Engineer J. Clayton, of Richmond, both of whom were injured. The locomotive and baggage car of the express were derailed.

Scranton, Pa., March 11.—By the breaking of the parallel rod of the engine of No. 1 passenger train on the Delaware, Lackawanna & Western Railroad, near Moscow, the boiler of the engine was pierced, and the escaping steam forced Engineer Albert Tingley, Fireman Matthew Deveren, and Ashman Edward Giles to jump from the cab. They were so badly injured that all three may die. Tingley was badly scalded about the hands and face. He also suffers severe pain in his back, and it is feared that his spine is seriously injured. Before he jumped he set the air-brakes and brought the train to a stop, thus averting a serious disaster. Giles is terribly scalded about the face, the flesh appearing to have been boiled. Davern's worst injury is his broken leg.

Hartford, Conn., March 13.—Locomotive No. 320, of the Philadelphia, Reading & New England Railroad, exploded at St. Elmo, N. Y., ten miles west of Poughkeepsie Bridge this morning.

George A. Shufeldt, fireman, of this city, and Horace Lambert, brakeman, of Bangor, N. Y., were instantly killed, and Engineer James Flannigan, of this city, was fatally injured.

The engine, which was making its first trip after having been thoroughly repaired in the shops here, was drawing an east-bound extra freight. The crown sheet gave way.

Bolingbroke, Ga., March 14.—The fast express on the Central Railroad was thrown from the track two and one-half miles from Bolingbroke. The engine and all the coaches except the parlor cars are in ruins. No lives were lost. The engineer, Ramsey, is seriously hurt and the fireman is slightly scalded.

Elkton, Md., March 15.—A freight wreck occurred at Northeast, on the Philadelphia, Wilmington & Baltimore Railroad. An extra north-bound freight train was side-swiped by another freight engine, derailing the engine and demolishing about a dozen cars. Joseph Howard, of Philadelphia, engineer, was slightly injured.

Hartford, Conn., March 16.—Two locomotives were wrecked and three cars derailed by a collision of freight trains at Simsbury. Engineer Jack Lynch, of Hartford, ran his extra freight into town at such a rate of speed that he could not stop in time and ran head on into train No. 33, which was at a standstill. Lynch and his fireman jumped, and the former's leg was broken and his face and body badly bruised.

Hazleton, Pa., March 16.—While Pennsylvania Railroad engine No. 409 was going down the mountain it became disabled and was run on to a siding. Swenk, the flagman, became confused, and turned the main switch. Lehigh Valley engine No. 525 came around the curve at a rapid rate of speed and dashed into the disabled engine. John Jenkins, a cook on the tool car, was badly injured. The car immediately took fire and was destroyed. Kleckner, the conductor of the Lehigh Valley train, had a leg broken, and Shuman, the engineer of the Pennsylvania train, had an arm broken.

Port Jervis, N. Y., March 16.—The engine of train No. 12 on the Erie Railroad broke down, which caused a halt of 15

minutes at Lackawaxen to await the arrival of another engine. While standing there, No. 12 was run into by train No. 10, the Buffalo express, which was closely following the Chicago train. The train was badly wrecked and fourteen passengers were seriously injured, some of them fatally.

Engineer Canfield and Fireman Boyd, of train No. 10, stuck to their engine until the crash came, and they escaped serious injury. They extricated themselves from the wreck and joined the passengers and train hands in removing the injured to the Lackawaxen station.

Butte, Mont., March 18.—A 55-ton Grant locomotive exploded with terrific force, instantly killing Engineer H. J. Winkerwoerder and Switchman John Kane; Engineer Paul Fetherkyle was fatally and Fireman James Mulligan seriously injured. The locomotive was owned by the Montana Union Railroad Company, and was ascending the hill with 12 empty ore cars for one of the Anaconda Company's mines.

Evanston, Wyo., March 18.—An east-bound Union Pacific express train ran into an open switch near this place, and the result was a bad wreck, in which B. F. Gay, a postal clerk, was killed and Engineer Lethbridge seriously scalded.

Mahanoy City, Pa., March 18.—A Reading locomotive exploded while standing on a siding near the station in the central part of the town. Engineer John Schuyler and Fireman William Wells, who were in the cab at the time, were thrown in the air and so badly battered and scalded that they cannot survive.

The hot coals from the fire-box were scattered in all directions, and, falling on buildings in the vicinity, set fire to and destroyed a number of them. At one time there were fully a dozen houses on fire.

Norristown, Pa., March 20.—Engine No. 884, with a coal train attached, ran off the track just this side of Pottstown, near Sanatoga, on the Philadelphia & Reading Railroad. After running along the ties for 20 yards it plunged down a 20-ft. embankment, carrying the engineer, John McCormick, aged 34 years, with it.

The fireman, Thomas McLaughlin, aged 27 years, jumped and escaped with a cut face and head; the engineer, with a broken arm and a severely shocked system. A broken rail is responsible for the damage.

Greensburg, Pa., March 21.—William McGough, engineer on one of the Derry local freights, was painfully injured in jumping from his engine near Radebaugh. Seeing an empty engine ahead of him, he became alarmed, and, reversing his engine, jumped off. He was thrown violently on the ballast, breaking his right arm, bruising his leg and sustaining a number of cuts about the head and face.

Brooklyn, Ia., March 21.—Engineer Le Clare met with a painful and serious accident Tuesday evening on the Chicago, Rock Island & Pacific Railroad, which will lay him up for several days. He was coming west on a fast freight, and his was the second engine of a double-header. East of here a piece of coal fell from the forward engine to the ground and bounded up just in time to catch the second engine. Le Clare was sitting on his seat in the cab and the coal came crashing through the window-sill and struck him upon the jaw. The wound proved both serious and painful. Le Clare was able to return to his home at Rock Island on the evening passenger train.

Worth, Ill., March 21.—William Johnson, a Wabash engineer, was instantly killed yesterday morning by a gas explosion. His train stopped here for water and coal, and three brakemen tried to remove the cap from the small oil tank on the engine. It was a hard job, and Johnson went to their aid, taking with him a wrench and his lantern. As he removed the cap the escaping gas which had accumulated became ignited and an explosion followed. Johnson was hurled nearly 100 ft., and when picked up was dead. The brakemen escaped with only slight injuries.

Bellevue, O., March 23.—The tender of a work train was derailed about 15 miles south of Bucyrus while backing, and dragged the locomotive with it down an embankment, and eight cars followed. Engineer Van Horne received a painful but not dangerous scalp wound. Fireman R. Sams received severe injuries in his hips and legs, besides internal injuries, the extent of which cannot yet be determined. The brakeman, Charles Jennings, of Columbus, ran back from the tender, jumping from one car to another as fast as they left the track, until he reached the ninth car, which remained on the rails.

Herkimer, N. Y., March 27.—Engineer Charles Barrett, of this place, was seriously injured in the accident on the Adirondack Railroad. He will probably recover.

New Haven, Conn., March 27.—Frank Stevens, a locomotive fireman on the Consolidated Railroad, while standing on the side of his locomotive was caught between the round house and the locomotive cab and badly pinched.

Philadelphia, Pa., March 28.—Several mischievous boys unfastened the brakes on a loaded gondola standing on the side tracks of the Reading Railroad near Park and Lehigh avenues, and in a few seconds it was going down the grade at a high rate of speed in the direction of Huntingdon Street, just below which it collided with a shifting engine in charge of Engineer David Hendricks. One side of the cab was torn from its fastenings, the steam fixtures were broken, and the engineer was forced from the footboard to the side of the track and badly scalded by escaping steam. The engine was stopped before any further damage was done.

Birmingham, Ala., March 30.—Two north-bound freight trains on the Georgia Pacific had a rear end collision at Waco, 111 miles east of here. Engineer William Gray, aged 25, was killed, and Fireman Lewis Mitchell fatally injured. They were in the engine of the second train, which, when it struck, turned over down an embankment, the engine falling on the men.

St. Paul, Minn., March 30.—A frightful accident on the Canadian Pacific Railroad, a few miles east of Harrison, which resulted in the loss of four lives. Among the killed is Stephen White, brother-in-law of Judge Killam, of Winnipeg. Reports are that the engine jumped the track while on a dizzy height, overlooking the Frazer River. The engineer and fireman, seeing no chance to escape by remaining in the cab, jumped for their lives into the deep gorge. The engine at the same moment went down the perpendicular embankment. Nothing was seen of the men after they jumped from the engine. Two others were killed, one being Mr. White. Nothing was learned of how he met his death.

Our report, it will be seen, includes 35 accidents, in which seven engineers and six firemen were killed and 18 engineers and 15 firemen were more or less seriously injured—some of them probably fatally. The causes of the accidents may be classed as follows:

Boiler explosions	5
Bursting of pipe	1
Broken crank-pin	1
Broken coupling-rod	4
Open switch	1
Derailments	4
Collisions	11
Land slide	1
"Side-swiped"	1
Jumping from engine	1
Struck by coal	1
Lost tire	1
Caught between locomotive and engine-house	1
Gas explosion in car	1
Unknown	1
Total	35

The Reading Railroad, as usual, leads in boiler explosions, and is credited with two. Four broken coupling-rods seems a large number for one month; and if we add the one broken crank-pin—probably due to the same cause—it should lead to serious inquiry as to whether this danger may not be lessened.

Collisions, as might be expected, are the chief cause of accidents. To prevent these entirely both human nature and the laws which govern inanimate things would have to be completely changed.

Our record has not been kept long enough to be very instructive, but it shows that, if the rate of mortality for March is an average for the year, 156 engineers and firemen are killed, and about 400 are injured annually in this country. Doubtless our record is very much below the real average, as the only means we have of getting reports of accidents is from the newspapers, and these are always imperfect.

We repeat our request, made at the beginning of this article, that persons in positions to hear of accidents to engineers and firemen should send us reports of them.

COLUMBIAN EXPOSITION NOTES.

The Bethlehem Iron Company's Exhibit.—This display will be the heaviest at the Columbian Exposition, weighing 1,000,000 lbs. There are four armor plates, a 17-in. plate for the *Indiana*, a nickel steel barbette weighing 70,000 lbs., an 11½-in. plain steel plate, a 10½-in. case of hardened nickel steel plate and a 6-in cylindrical ventilator for the *Puritan*.

A United States Army Balloon.—It is reported from Washington that General Greely has purchased from the French baloon-maker, Lachambre, a military balloon, which is to form a part of the War Department's exhibit at Chicago.

The balloon has a capacity of 13,000 ft. and will cost 9,000 francs. It is to be made of goldbeater's skin, and the contract

price includes basket, ropes, sandbags, drag, and other accessories of military balloons.

A detachment of Signal Corps Sergeants will be sent to the Exposition grounds to join the force already there, that practical illustration may be given of the methods of signaling in the army, including the operation of this military balloon. It is said that this will be a "regulation, globular, captive balloon," attached to the basket of which is a light wire, extending to a huge reel, which allows the wire to unwind as the balloon ascends, and serves to pull the balloon back to camp. The wire has a double use, in holding the balloon and furnishing the occupants of the basket a means of communicating, as by telephone, with the officers at the reel.

Indiana's Coal Exhibit.—The Indiana coal operators have arranged to make an elaborate exhibit, the block coal interests to be represented by the Brazil Block Coal Company, and the bituminous mines by the Foley Mine. The latter was agreed upon for the reason that it can furnish a larger block of coal than any of the other bituminous mines, owing to the mine's lesser depth. The block of coal from the Foley Mine will be over 7 ft. in height. The other mines in this vicinity will also make exhibits. The Hocking Valley will have on exhibit a block of coal showing a vein 16 ft. 3 in. in height, and New South Wales will have coal from 10-ft. veins, but the latter, owing to the presence of sulphur, is not so good as either the Hocking Valley or the coal of this district. Governor McKinley has placed Ohio's coal exhibit in charge of the State Mine Inspector, and the operators of this State will urge Governor Matthews to put Mine Inspector McQuade in charge of Indiana's exhibit. It is believed that such a plan would largely enhance the merits of an industry that is second to none in the State's wealth.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

II.—METHOD OF DETERMINING FREE CAUSTIC AND CARBONATED ALKALI IN SOAPS.—*Continued.*

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page 200, Volume LXVII.*)

NOTES AND PRECAUTIONS.

It will be observed that the method above given for determining carbonate of soda in soaps is based on the insolubility of this salt in a solution of soap in absolute alcohol, and that the method for getting the free caustic alkali dissolves the soap in presence of an acid which cannot decompose it, which has but slight action on the carbonate present, and which combines with the free caustic alkali as fast as solution takes place, and enables this constituent and the small amount of carbonate dissolved to be measured.

Positive experiments show that with good absolute alcohol, and with soap which has been freed from water, the carbonate determination is very sharp, the salt being almost absolutely insoluble. Many soaps in the market, however, contain from 5.00 per cent. to 35.00 per cent. of water, and if in addition to this water in the sample 95.00 per cent. alcohol only is used, the solubility of the carbonate of soda becomes quite perceptible. The error in these cases may amount to from 0.10 per cent. to 0.30 per cent. Many of the common soaps contain as high as from 5.00 per cent. to 7.00 per cent. of carbonate of soda, and in such samples this error may perhaps fairly be ignored. Whether absolute alcohol or 95.00 per cent. alcohol is used, it is always desirable to dry the soap, and if this is done, the error, even when 95.00 per cent alcohol is used, is not much over 0.10 per cent. It is believed that if the directions are closely followed in every respect, the error can always safely be ignored.

The solubility of soap in absolute alcohol is apparently not quite as great as in 95.00 per cent. alcohol, and therefore after solution is complete, filtration must proceed with moderate rapidity, or the solution may gelatinize and clog the filter. There is less danger of this the hotter the solution is kept.

If the soap under examination contains uncombined fat acid along with carbonate of soda, as is frequently the case in olein soaps, combination may take place between these constituents in the boiling absolute alcohol solution, and consequently the analysis may be in error to this extent. We do not know of any method of overcoming this difficulty.

The drying of soap is a slow operation at best. It is facilitated by having the shavings very thin, and by having the temperature of the air surrounding the soap at first not hotter than 120° Fahrenheit, and gradually, as the drying proceeds, raising the temperature to not above 200° Fahrenheit. Of course the soap must not be melted, as this would endanger the combination of some of the free or carbonated alkali with free fat, if any were present. Experiments indicate that if the amount of water in the dried soap does not exceed 5.00 or 8.00 per cent., the resulting error can be ignored.

The stearic acid solution, as made from commercial materials, is sensitive to changes of temperature. It is, therefore, essential to prevent it from becoming too cold, or its strength will be diminished by something crystallizing out.

Most of the commercial 95-per cent. alcohol does contain, and the absolute alcohol may contain small amounts of free acid of some kind—probably acetic. The amount of this can readily be determined by the use of standard alkali, and in the carbonate determination this acid must of course be allowed for.

Much of the phenolphthalin of the market apparently contains something which combines with alkali without showing change of color. If this is not satisfied with alkali as directed, the reaction will not be quite so delicate.

We make standard sulphuric acid solution by adding to a clean, clear glass 5-gallon bottle, 15 liters of distilled water, and then weigh out and add to it 397.5 grams of concentrated C. P. sulphuric acid. It is better to set the water in the bottle in motion by stirring with a clean glass rod before adding the sulphuric acid. After the acid is in, it is essential to agitate thoroughly by stirring and shaking, but not advisable to draw air through for this purpose, as this causes the liquid to take up carbon dioxide, which interferes with its subsequent usefulness with phenolphthalin. It is not desirable to standardize on the same day, both on account of temperature and also because, if we may trust our experience, it is very difficult by any practicable method of agitation to get so large a bulk of liquid entirely homogeneous without standing. If the first standardizing shows that it is essential to add say 750 c.c. of water, we usually add only 700, since we expect to standardize once more any way, and too much water must of course be avoided. The second addition of water is usually less than 100 c.c. We regard both agitation and standing over night essential after each addition of water.

We make caustic potash solution in the same kind of bottle and in the same amount as the acid solution. The same precautions should be taken in regard to stirring, and allowing to stand over night, as in the case of the acid. It is well known that caustic potash solution, if properly made as above described, contains a small amount of caustic lime in solution. Of course this lime will appear in the comparison with the standard acid. If now the water used in the first addition contains a little carbon dioxide, a little of the lime will be precipitated on standing over night, and weaken the solution a little. It is therefore not advisable to add quite as much of the water shown by calculation the first time, as in case of the acid.

We make the two solutions, as will be observed, in quite large amounts, and take considerable pains to have them right, since other work depends upon them. The bulk above described lasts us four or five months. Both of the solutions are kept on a shelf somewhat higher than the burettes, and both are drawn into the burettes by means of glass tube siphons with glass cocks at the lower ends. In accurate work it is of course essential to draw out and throw away the liquid which has been standing exposed between the cock and lower end of the siphon tube before filling the burette. The air which goes in to replace the liquid in the large glass bottles should bubble through caustic potash solution in order to keep out carbon dioxide. We use potash bulbs for this purpose.

The fact that phenolphthalin is sensitive to carbon dioxide in water solution, and to carbonates and bicarbonates, may lead to serious error unless sufficient care is taken to add enough acid to decompose all carbonates and bicarbonates and then expel the gas by boiling before subsequent titration with caustic potash. An illustration will make the matter clear. Let

us suppose that in obtaining the relation between carbonate of soda and sulphuric acid in standardizing the acid, the carbon dioxide is not quite all removed by boiling, when we attempt to measure the excess of the acid by means of the caustic potash solution. We add this solution drop by drop, and ultimately reach a point when all the free sulphuric acid is satisfied with the caustic potash; but since phenolphthalin in presence of carbonic acid or carbon dioxide in water solution does not change color until part, at least, of this carbonic acid is also satisfied with caustic potash, we do not get our end reaction when the sulphuric acid is all satisfied, as should be the case, but rather after some further addition of caustic potash. The error is obvious; and if we may trust our experience, there is always uncertainty if carbon dioxide or carbonates are present when using phenolphthalin as indicator. Even carbon dioxide in the standard sulphuric acid solution or carbonates in the caustic potash solution will cause difficulty. Methyl orange, and possibly other indicators, do not give so much trouble from this cause; but all that we have ever tried are so much less sensitive and sharp at the end reaction than phenolphthalin, provided the conditions are right, that we prefer to take the extra trouble. Furthermore, positive experiments show that if the solution is rendered clearly acid with standard acid and boiled for 10 minutes or even less, the carbonic dioxide will all be expelled; so that we think if the directions are closely followed the results will be fairly accurate. It is obvious that if the distilled water used in making the standard acid contains carbon dioxide, there will always be some present, with a consequent liability to uncertainty in the final results. Presence or absence of carbon dioxide in the standard acid can be proved by titrating some of the acid cold with standard caustic potash, using phenolphthalin for indicator, and then titrating another similar portion after it has been boiled. If carbon dioxide is absent, the two tests should show the same figure. If it is present in injurious amount it will be essential to always boil to expel carbon dioxide in all tests where this acid is used before attempting to titrate in presence of phenolphthalin.

It is obvious if a soap contains more free alkali than is sufficient to combine with all the stearic acid in 100 c.c. of the stearic acid solution taken, it will be necessary to either use more of the stearic acid solution or diminish the amount of soap to start with.

If a soap has silicate of soda in it, this apparently breaks up in the stearic acid solution, part of it counting as caustic soda and part of it remaining behind on the filter, possibly as insoluble acid silicate of soda. Borate of soda also breaks up in the stearic acid solution, and part, at least, of the base counts as free caustic alkali. We have never carefully investigated the behavior of these substances in the absolute alcohol solution, as, if either of them are present in any perceptible amount, the soaps would not fill our specifications.

It will be observed that in the calculations the results are reported in terms of soda salts. This is because our specifications for soap are so drawn. Of course the results could be reported in potash salts equally well.

We usually calibrate burettes by filling them with distilled water at about 70° Fahrenheit, and then draw out into a flask, and weigh each 5 c.c. to the bottom, and then fill again and start 1 c.c. lower down, and proceed as before. Two or three times through in this way will check any discreppancies that will seriously affect the result. Of course each 5 c.c. should increase the weight 5 grams, and if the burettes are fairly well graduated the differences should not be over the weight of one drop, approximately 50 milligrams. Obviously by using a good balance and going through the burette times enough, the calibration can be made as fine as the graduation. We do not, however, regard this as necessary. It is hardly necessary to add that the burettes to be used with the standard acid and alkali must be alike, or, indeed, interchangeable.

It is well known that change of temperature affects all volumetric work, and it is equally well known that there is no error from this cause if the solutions are used at the same temperature at which they are standardized. We usually keep our standard solutions on a shelf near the ceiling of the room, where the temperature is about 80° Fahrenheit, and standardize them finally after they have been at this temperature over night. With most of the determinations for which we use these solutions, a change of temperature of 10° Fahrenheit does not introduce a greater error than would be produced by one drop of the solution in excess. As we cannot work closer than one drop, except by using weaker solutions, the error of temperature is usually ignored. Of course in very fine work care should be taken to use the solutions at the temperature at which they are accurate.

It is of course well known that other materials than carbonate of soda have been recommended as the starting-point in making acid standard. It is entirely possible that some of these are better than carbonate of soda, but it is believed that if the directions are closely followed, the results will be fairly accurate.

The use of stearic acid to combine with and measure the free caustic alkali in soaps is believed to possess advantages which do not inhere in other acids. First, the solution keeps unchanged almost indefinitely, which is not the case apparently with oleic, and possibly not with palmitic, both of which, as well as stearic, may be constituents of soap, and both of which might possibly be used in place of stearic. Second, the soap apparently not being decomposed, no question can arise as to whether recombination takes place in the same way during the subsequent titration. Third, stearic acid is so weak that its action on carbonate of soda, even in boiling alcoholic solution, is slow and if the soap is cut in quite thin layers, and titration takes place as soon as solution is complete, the carbonate dissolved does not amount to more than 0.25 per cent. Fourth, many of the strong mineral acids act on the organic constituents of the soap, and hence their use is admissible. Also all the stronger acids, even organic ones, dissolve carbonate of soda quite readily, as well as decompose the soap.

It is obvious that there may be a number of conditions in soaps obtained in the market. First, there may be an excess of unsaponified fat, arising from failure of the soap-maker to use enough caustic alkali. In this case, if there is also no carbonate present, the method as described above shows nothing; that is, the titration of the stearic acid at the end of the operation gives the same figure as the titration of the stearic acid alone. We have had cases of this kind happen in our experience. It is obvious that the addition of a known amount of alkali in alcohol to a case like the above, with subsequent boiling and determination of the excess of alkali, would give the amount of unsaponified fat present. We have not experimented with this, however. If carbonates are present, some of the stearic acid would be used up, since this acid in boiling alcoholic solution acts slowly on carbonates, and it would require a carbonate determination as described before it could be stated that the soap is free from caustic. This statement of course involves the idea that unsaponified fat in a soap is not decomposed by carbonate of soda in boiling absolute alcohol solution, as described in the carbonate determination. We have not proven this, however, our experiments only showing that carbonate of soda is insoluble in a boiling solution of soap in absolute alcohol. It would almost seem safe to conclude from this, however, that since carbonate of soda is insoluble, it could not act on free fat. Second, there may be an excess of free fat acid in the soap, owing to the same reason as before —viz., failure to add enough alkali. This is liable to be the case with soaps made from rosin, and in the so-called olein soaps. In this case the method as described, if no carbonates are present, enables the amount of this free fat acid to be determined. The titration of the solution actually gives a higher figure than the stearic acid alone, the excess of course being due to the free fat acid in the soap. We have had many cases of this kind. If carbonates are present in amount just sufficient to satisfy the free fat acid in the soap, and if the boiling is continued long enough so that these carbonates are just decomposed, neither the method for determining carbonate nor that for determining caustic will reveal this fact. For all other proportions of carbonates along with free fat acid in a soap, the methods given enable close approximations to the facts to be obtained. Third, there may be free caustic alkali along with free unsaponified fat. In this case, whether carbonates are present or not, the methods as given are applicable, and give the actual state of affairs in the soap. Fourth, there may be free caustic alkali along with free fat acid. In this case, if carbonates are not present, and if the amount of caustic is just sufficient to satisfy the free fat acid, neither of the methods reveal the facts, since the free fat acid and free alkali would combine on solution of the soap. For all other proportions of free caustic alkali an approximation to the state of affairs may be obtained by the methods as given. If carbonates are present along with free fat acid and free caustic alkali, and if the amount of both of these is just sufficient to satisfy the free fat acid, neither of the methods reveal the facts. For all other proportions the same remarks apply as above. Fifth, there may be free caustic alkali along with normal soap. In this case, whether carbonates are present or not, the methods are applicable, and reveal the state of affairs. It is obvious from the above discussion that soaps containing free fat acid along with just enough caustic and carbonated alkali to combine with the free fat acid cannot be successfully examined by the methods given. It is believed that in all other cases the methods given enable a satisfactory opinion to be expressed in regard to the soap.

(TO BE CONTINUED.)

PROCEEDINGS OF SOCIETIES.

Civil Engineers' Society of St. Paul.—At the monthly meeting, held on April 3, Mr. Eastabrook read a paper on the Isthmus Canals and their Relations to a Deep Water-way between the Great Lakes and the Atlantic Seaboard at New York. He gave a history and description which was fully illustrated by maps of the Suez, Panama, Nicaragua and Erie canals, touching lightly upon exhausted tables of statistics, and closing with the expression of some broad views on the subject of canals.

The Montana Society of Civil Engineers.—At the April meeting Mr. A. E. Cummings read a paper on the West Gallatin Irrigation Canal, in the course of which he said that his experience led him to believe that about 1¼ miner's inches of water per acre were required for proper service for irrigation in Montana.

In the discussion President Haven said that he had recently measured the amount of evaporation for a reservoir having a surface of 46 acres, and an average depth of 12 ft. No water had been drawn from the reservoir for one year and none supplied except by rainfall; there was little seepage, and the total evaporation for the year amounted to 10 in.

Liverpool Engineering Society.—At the meeting of March 8 Professor H. S. Hele-Shaw read a paper on the Graphical Method of Solving Engineering Problems. It was pointed out that a very large proportion of graphical statements take the character of either Cartesian diagrams or polar diagrams. Various text and pocket-books were referred to in which were seen the increase of plotted curves for representing the proportion of valves, the proportion of belts, ropes, screw propellers, boilers, the teeth of wheels, girders, pipes, bolts, coal consumption, etc. Another use of plotted statements are plotted tables for numerical calculation, such as the abacus of Lalanne.

Inquiry was made into the graphical methods of operation which correspond to arithmetical or algebraical operations. Just as we have books in algebra, such as addition, multiplication, progression, etc., we may naturally look for graphical rules and processes which shall enable us to perform similar operations.

Coming next to the actual mode of graphical operation, the author said that we may place first and foremost, in utility, simplicity and frequency of employment, the method of "interpolation," which merely consists in finding from any graphical statement in the form of a continuous curve an intermediate value by drawing a line at the point required, as, for instance, to find the pressure in an indicator diagram at any given stroke.

The actual graphical operations other than the mere construction of linear and polar diagrams were then considered at some length. Examples of cranes, roof-truss and other diagrams were taken, and the method which is known as "Culmann" was given, after which the author concluded by saying that the few examples which were given in the foregoing paper were sufficient to indicate the wide field which is opened out by graphical processes, the possibilities of which seemed almost infinite. And now that modern or projective geometry, which deals not merely with plane surfaces, but with lines in space, had been directly applied—first by Culmann, and since by other writers—to the subject of graphical statics, there appears to be no limit to the number or variety of engineering problems which may be thus dealt with. What is wanted at the present time is a clearer understanding of the foundations of the subject, so as to collect and bring into a more definite system the rapidly growing number of problems and publications of all kinds which deal with graphical statements and operations.

American Society of Civil Engineers.—A paper was read at the meeting of April 5 by Walter McCulloh on a Water-tight Masonry Dam. The dam described was the Sodom Dam on the Croton Aqueduct. The greatest height of the dam above the rock is 98 ft., and the thickness at the bottom is 53 ft.

The emergencies which have to be guarded against in the construction of the dam lay in the fact that the stream rises very suddenly, and the discharge in the spring freshet sometimes reaches 250,000 cub. ft. per minute. To control this during construction, a timber crib dam was thrown across the river about 80 ft. above the site of the work, and a canal cut 26 ft. wide and 15 ft. deep on the west side and around the work to a point 500 ft. below. The gate-house and eastern half of the dam were then built to about 35 ft. above the discharge pipes, and in the dry season of 1889 the water was turned through the pipes and the other half of the dam started.

In preparing the foundation, all loose rock was removed, and afterward all loose seams or shakes. The foundation was swept with wire stable brooms and washed clean. All pockets or holes were then filled with rich Portland cement concrete. A tighter bond, it was found, could be made with rubble consisting of small stones than with concrete beds. Water entered through several seams in the rock, and would wash the mortar out of the concrete, but it could be led around the rubble beds, until finally a small well 2 ft. in diameter and 1 ft. deep was formed at the point where the water boiled up. After the mortar had set, the well was bailed out and filled quickly with dry mortar; on top of this a bed of stiff wet mortar was laid, and capped by a large rubble stone. After the first 6 ft. of the rubble foundation had been placed there was no further trouble.

The dam for about 40 ft. of its height is of rubble masonry laid in Portland cement mortar mixed 2 to 1. Above this there was facing stone 30 in. deep, laid in 2 to 1 Portland cement mortar, backed with rubble in mostly 2 to 1 mortar. The rubble stones varied from a cubic foot to a cubic yard in bulk, and were laid in full beds of mortar. There were no through horizontal joints. Joints were filled with mortar, into which as many stone spalls were forced as was possible. All stone was washed before using. Sand and cement were mixed dry, and then wet only when required. All cement passed through a sieve of 10,000 meshes, and was carefully tested. All loamy sand was rejected. The face stone was a light bluish gray limestone, cut rectangular, with rock face. Stretchers were 3 ft. to 6 ft. long × 30 in. wide, and headers 4 ft. long. The thickness of courses diminished from the bottom up. The beds were at right angles to the face, and the stone had to be held in place with wooden blocks and wedges, to prevent slipping until the mortar had set, after which the blocking was removed and spaces left were filled with rubble.

Stone setting was done by the use of the cable, the traveler and derricks. The cable consisted of a 2¼-in. steel-wire cable, stretched over and parallel to the dam, and over towers 667 ft. apart, and anchored in the bedrock. On this a trolley ran which was worked by a double-drum reversible engine. A load of 10 tons would sag the cable 25 ft. with a clearance of 5 ft. above the coping. Most of the excavation was removed, and all material delivered on the wall in this manner. The cost of the cable erected was $3,750. The first cable after 15 months' use parted without warning, under a load of 6 tons, the break being probably due to unequal wear at the point where stone and cement were hoisted. The towers were then raised 10 ft., so as to lessen the tension, and a new cable supplied which lasted until the completion of the work. When the wall had reached a point 31 ft. below the top, the standing derricks were replaced by a traveling derrick mounted on a 30-ft. trestle and running on a track of 36-ft. gauge; a boom 55 ft. long was used with this derrick.

The dam is water-tight. With 68 ft. of water behind it no leaks whatever have been found, either through or under the wall or around the ends. Sweating at the joints appears at points, but not so much as to cause a trickle; but it cannot be seen on a dry day. This very desirable result is due to the excellent materials used, the care in preparing the foundation, thorough cleaning of all stone, care in mixing mortar, breaking of joints horizontally and vertically and close attention by the engineers to every detail. In addition to this, the desire on the part of the contractors to do good work and the existence of a proper relationship between them and the engineers were factors.

PERSONALS.

Mr. J. C. Halladay succeeds Mr. E. J. Hill as Western representative of the Pickering Steel Company, with office at 719 Phœnix Building, Chicago, Ill.

Mr. James G. Dagron, member American Society of Civil Engineers, has resigned his position as Engineer of Bridges of the Baltimore & Ohio Railroad.

Mr. Theodore Cooper, of the Class of 1858, delivered a lecture on "Specifications" before the students of the Rensselaer Polytechnic Institute, at Troy, on March 29.

Mr. Edward J. Hill, formerly Western representative of the Pickering Steel Company, Limited, has been appointed General Sales Agent, with headquarters at Room 14, No. 80 Broadway, New York City.

W. H. Fry has been appointed General Superintendent of the Car Department of the New York, New Haven & Hartford Railroad. He is to have full charge of all matters per-

taining to the cars and car shops of the Company wherever they may be.

MR. J. R. KENDRIK, General Manager of the Old Colony Railroad, has been appointed Third Vice-President of the New York, New Haven & Hartford Railroad.

MR. DUDLEY D. MAYO has been appointed Acting Manager of the Denver & Rio Grande Express, in the place of Mr. George W. Kramer resigned.

MR. A. E. MANCHESTER, formerly Division Master Mechanic, has been appointed Assistant Superintendent of Motive Power of Chicago, Milwaukee & St. Paul Railroad, with office at Milwaukee, Wis.

MR. BLAINE GAVETT has been appointed District Passenger Agent for the Chicago & West Michigan Railroad, the Detroit, Lansing & Northern Railroad and leased lines, with office at 120 Griswold Street, Detroit, Mich.

L. W. BRADLEY, for a number of years Purchasing Agent, of the Brush Electric Company, resigned recently. H. J. WENDORFF, who has been for a long time at the head of the store rooms of the Brush Company, was appointed in his place.

MR. EDWARD B. WALL has been detailed for duty as assistant to the First Vice-President of the Pennsylvania lines west of Pittsburg, with office at Chicago. He will have charge of the general interests of the lines (excepting traffic) at that point.

ALFRED P. BOLLER, of the Class of 1861, recently delivered a lecture before the students of the Rensselaer Polytechnic Institute on the Substructure and Approaches of the New Central Bridge over the Harlem River at One Hundred and Fifty-fifth Street, New York.

JACOB S. ROGERS, the millionaire owner and President of the Rogers Locomotive Works, has retired from active management of the business. The business will be carried on under the name of the Rogers Locomotive Company, with a capital stock of $3,000,000. ROBERT S. HUGHES, formerly Secretary, will be President of the new company.

MR. FREDERICK A. SCHEFFLER, Superintendent of the Brush Electric Company, has tendered his resignation, same to take effect April 1. Mr. Scheffler has for several years past been actively identified with the manufacture of electrical apparatus, and for a number of years previous was engaged in the production of steam-engines and boilers. His address after April 1 will be "Passaic, N. J., care E. K. Rose."

MR. J. VAN SMITH, Superintendent of the Philadelphia Division of the Baltimore & Ohio Railroad, has, in addition to his above-named position, been appointed General Agent of the Company for Philadelphia, the appointment dating February 1, 1893. He will be the authorized representative of the Executive Department of the Company, and will report directly to the respective heads thereof. For the present his office is at the Baltimore & Ohio Railroad Station, Twenty-fourth and Chestnut streets, Philadelphia, Pa.

OBITUARIES.

MR. JOHN TAYLOR JOHNSON, first President of the Central Railroad of New Jersey, died in New York City on March 24, in his 73d year, of paralysis. Mr. Johnson's reputation outside of railroad circles was very wide as a collector of fine paintings and as the founder of the Metropolitan Museum of Art in Central Park, of which he was President up to 1889. He was a lawyer by profession, but practised only a few years, having been elected when 28 years old to the presidency of the Elizabethtown & Summerville Railroad. He was President of this railroad and of the New Jersey Central, of which it formed a part, from 1848 until 1877, when he lost most of his fortune through the disasters that at that period affected all of the anthracite coal-carrying roads. He resigned in 1877, and was not associated with the road after that.

MR. D. H. NEALE, who has, for a number of years, been identified with the editorial staff of the *Railroad Gazette*, died in Brooklyn on Wednesday evening, April 5, of cerebral meningitis. He was born in England, September 5, 1849, and practised there as Mechanical Engineer for some years. At one time he was Chief Draftsman of the London & Northwestern Railroad, but later went to Cape Colony as Assistant Locomotive Superintendent of the colonial railroads. He came to the United States in 1883 to represent the *Engineer* at the Chicago Exposition of Railway Appliances, and in November of the same year joined the editorial staff of the *Railroad Gazette*, on which he remained until November, 1888, when he resigned to go to Sydney, New South Wales, as Mechanical Engineer. He returned to the United States in November, 1892, and rejoined the editorial staff of the *Railroad Gazette*. Since that time his principal work has been that of editing a new edition of the "Car-Builder's Dictionary." Mr. Neale possessed a remarkable combination of faculties, and one which especially fitted him for editorial work. He had a keen mechanical insight and a good power of analysis, and, added to this, his facility in the use of language was quite remarkable, for everything which he wrote was characterized by being couched in the purest and most elegant English. His loss is one that will be very seriously felt in the world of technical literature.

CHARLES R. PEDDLE, one of the best known railroad officers in the West, general purchasing agent of the Vandalia line, died Wednesday, at Terre Haute, Ind. He had been connected with the Vandalia continuously since it was built by Chauncey Rose in 1851 as the Terre Haute and Indianapolis Road, and he was Superintendent and Master Mechanic in years past. He purchased the first four engines used on the road of Hinckley in Boston in 1851, and superintended their removal to Terre Haute, a difficult undertaking in those days. Mr. Peddle's daughter, Miss Carrie Peddle of this city, is the artist selected by St. Gaudens to design the model for the Isabella coin for the World's Fair.

THE NEW YORK CENTRAL RAILROAD EXHIBIT AT CHICAGO.

THERE has just been completed at the West Albany shops of the New York Central Railroad two trains which will form part of the exhibit of this Company at the Columbian Exhibition. One of these consists of the old locomotive *De Witt Clinton*, which has been rebuilt from old drawings still extant, and from the personal recollections of Mr. Buchanan and others who remember the original machine. The old machine has been reproduced as exactly as possible in every particular. It is not a model, but a complete locomotive which has been run under steam. In addition to the locomotive three old cars have also been rebuilt like those which are represented in the silhouette, which has been extensively circulated, and is said to represent the first railroad train in America. This is, of course, an error, but does not detract materially from the interest in the illustration, which is a faithful representation of one of the trains on the Mohawk & Hudson Railroad in its very early days. The locomotive referred to and the cars are a faithful reproduction of the train represented by this old illustration.

In contrast with this is the new engine, No. 999, which Mr. Buchanan has built to represent the practice of to-day. It is very similar to the engine which has been the subject of the illustrations in the series of articles on American and European Locomotives, which are now being published in our pages. This exhibition engine has 7 ft. 2 in. driving-wheels and 19 × 24 in. cylinders. It is one of the finest pieces of work ever turned out in this and, it is safe to say, in any other country. The engine is plainly finished, with little or no useless ornament. The only decorative features are some finished or polished work, which would not ordinarily be put on an engine designed alone for actual service, and some very plain striping, which is done in silver. What attracts attention is the splendid workmanship of every part. The tank work on the tender has never been equalled in this country, and probably not surpassed in European shops, where, it must be admitted, they generally beat us in this especial department. Every part of the engine is finished to correspond with the other parts. The engine and tender are painted plain black, and, as already remarked, with silver striping. All the copper pipes and brass work is silvered so as to correspond with the painting. There are no especial features about the construction of the engine to note, excepting that it is a magnificent piece of work.

The new engine and the rebuilt *De Witt Clinton* and the three cars were all brought to New York, and were exhibited for several days in the Grand Central Depot, where they attracted a great deal of attention. The contrast between the train of 1832 and the new engine and cars of to-day was very striking.

A train of new cars has also been built to accompany the new engine to Chicago, but these were not sent to New York. Some of these are 70 ft. and others 72 ft. 6 in. long over the bodies, the total length being from 80 to 81 ft. over all. The car shop in West Albany is 75 ft. wide. This it was supposed would be ample for all the requirements of any cars that

would ever be built. In the construction of these new cars it was necessary to let them project some distance outside of the doors of the shop. All the cars will be vestibuled.

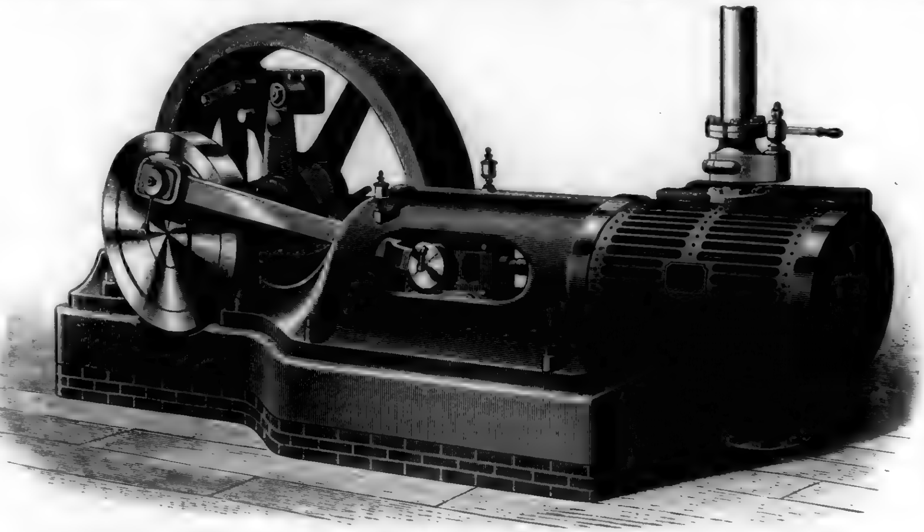
The whole of this work was done under the supervision of Mr. William Buchanan, Superintendent of Motive Power, and reflects great credit on his skill and sound judgment in every particular.

Manufactures.

AN ELECTRIC RAILROAD ENGINE.

We present an illustration of one of a particular class of stationary steam-engines which has been developed in the past few years—that is, since the adoption of electricity on street railroads. This service is such an extremely irregular and severe one that it requires an engine especially adapted to it. Probably in no other line of work is it possible to change the load so rapidly and so extremely, running in an instant from no load to full rating, and oftentimes much beyond it. This requires, in the first place, a very sensitive and yet stable governor; secondly, an economical engine under all loads; and thirdly, great durability to sustain sudden and continued shocks. This latter can only be obtained with ample wearing surfaces and plenty of metal, combined with good workmanship, distributed in such a manner as to give each part a strength equal to all, and far in excess of any strain which can possibly fall upon it.

Such an engine must necessarily be an expensive one in first cost, but even for other work than railroading it will easily prove a better investment the longer it is in use. The engine illustrated here is manufactured by the John T. Noye Manufacturing Company, of Buffalo, N. Y., and is known as the "B" style pattern. It is made in sizes ranging from 125 H.P. to 600 H.P., both in single cylinder and tandem compound. The bed, as will be seen, is extremely heavy and massive, containing both top and bottom cross-head slides. These slides are bored, and are very ample in their proportions. The main bearing is provided with quarter boxes, so that it can be taken up at all points. The cylinder on the single-cylinder engines is overhung, and in the tandem compounds there is usually a support placed under the high pressure cylinder. The strength of the bed and of the top slide renders it so stiff that even if there were a tendency to spring in the cylinder it would be impossible. The valve is of the ordinary grid-iron pattern, having four ports; but, unlike the majority of valves, this takes steam from both the inside and the outside, being balanced against everything except a slight exhaust pressure. The steam chest proper is contained within the exhaust chest, and forms a double surface for the valve. While the chest which is shown in the cut is ordinarily used as a steam chest, it is the receptacle of the exhaust. A very desirable feature of this construction is the fact that the engine can be turned over and operated with the exhaust chest cover off, so that if at any time there is a leak in the valve it can be discovered and easily taken up. It also prevents any excessive pressure upon the valve stem stuffing-box and upon the exhaust chest cover joint, which points are frequently a nuisance from leakage produced by an excessive steam pressure. The piston-rods, connecting-rods and main shaft are all of the best forged steel and of very ample proportions. The connecting-rod is provided with a loop at the crank-pin end, in which the brass boxes are set, so it is really impossible for the connecting-rod to let go entirely, even should the wedges or bolts become loose. The governor is placed within the band wheel, and is the form known as shaft governor. It is large, with ample power to control the whole of the valve motion, so that when desired in compounds, both the high and low-pressure valves can be handled with the same governor. The simplicity of the governor is apparent at a glance, and contains as few wearing points as possible. The points of adjustment and its strength give it the ability to handle the engine under any load and under the most varying loads. It is said that these engines frequently run on ½ of 1 per cent. regulation, and that without any tendency to race whatever.



AN ENGINE FOR ELECTRIC RAILROADS

Attention is also called to the fact that the engine has a side crank, which gives it a very desirable advantage, as all the working parts of the engine are directly in front of the engineer in charge, and are very accessible, so that they can be reached at any time.

The oiling devices are all complete, and in most cases the best class of sight feed stop oil cups are used, though in some cases the separate tank and pipe lines are applied, so that every part is oiled from the same source.

IMPROVED BOLT HEADING MACHINE.

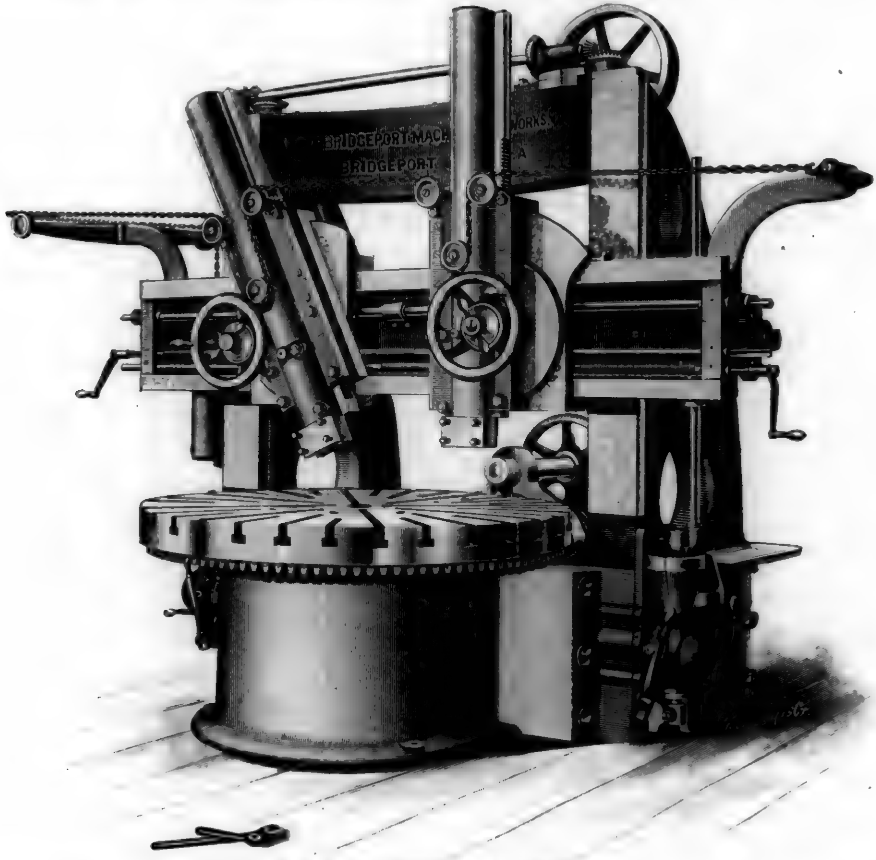
We illustrate on page 257 a new improved bolt heading, upsetting and forging machine built by the Acme Machinery Company, of Cleveland, O. The bed is made in the box form, with three deep trusses running through its entire length to give it great strength. The crank-shaft, which is made of the best forged iron, is carried in three bearings; the face of the bearings being inclined toward the front of the machine, brings the thrust of the forging tools and die closing mechanism against solid metal, and relieves the main caps and cap bolts from all strain. None of the parts subject to wear slide directly upon the bed of the machine, but upon steel and phosphor bronze strips or ways which may readily be removed to be trued up or replaced, thus saving the trouble and expense of

dismantling the entire machine and taking it to the machine shop should repairs be made necessary by such wear as does take place. The machine is also provided with a cushion clutch stop motion, so that when making special forgings, one or more blows can be given as may be required to finish the work. The dies and punches are of novel construction, and will turn out perfect square and hexagon head bolts in three blows or revolutions of the machine. Rivets, track bolts, and many other forgings are made right off the rod, and cut to length by a shear provided in the rear of the dies. An outside shear is provided for, which can be used for cutting off work from the bar after forging. A patent relief wedge serves to prevent the breaking of the bed through the feed gap, should the operator by accident or carelessness allow cold work to get caught between the dies. This illustration is from their 2-in. machine, weight of which complete is about 30,000 lbs.

NEW 62-IN. BORING AND TURNING MILL.

The machine illustrated is manufactured by the Bridgeport Machine Tool Works, E. P. Bullard, proprietor, Bridgeport, Conn., and is the result of eight years' experience in the manufacture of tools of this class. It embodies all the essential features of their smaller mills, and contains many new ideas which have been suggested by past experience. This company have recently enlarged their works and added many special tools and fixtures for making and handling machines of this character.

The capacity of the mill is 62 in. in diameter and 42 in. in height. The table is 58 in. in diameter, is powerfully geared and has 16 changes of speed. The teeth on table, as well as on pinion, are accurately planed. The heads are constructed so that either one may be brought to the center, and can be set at any angle—they carry the tool bars, which have a movement of 30 in. Each head has an entirely independent feed in any direction. The feeds are all positive, and range from $\frac{3}{64}$ to $\frac{3}{4}$ in. horizontally, and from $\frac{1}{64}$ to $\frac{3}{8}$ in. in angular and vertical directions. The cross-rail is raised and lowered by power. The machine is self-contained, thus avoiding the necessity for building an expensive foundation, and weighs 20,500 lbs.



NEW 62-INCH BORING AND TURNING MILL.

General Notes.

The Baltimore & Ohio Railroad is asking bids on a large number of freight cars.

The Eppinger & Russell Creosoting Works removed their office on April 1 to the Morris Building, corner of Broad and Beaver streets, New York.

The New York Central & Hudson River Railroad Company have placed an order for 1,200 freight cars, which are to be equipped with the New York Air-Brake Company's improved automatic freight-car brakes.

The Wheeler Condenser and Engineering Works of Carteret, N. J., recently cast a very large steam cylinder for the new steamer building for the Old Colony Steamboat Company. The gross weight of the cylinder is about 38,000 lbs.; it is 95 in. diameter by 11 ft. piston stroke, and some $2\frac{1}{4}$ in. thick, bored, and is a very handsome piece of work.

Preventive of Timber Rot.—According to *La Génie Civil*, timber may be rendered impervious to damp and to steam by use of the following composition: Sulphur, 50 parts; resin, $37\frac{1}{2}$; and fish oil, $7\frac{1}{2}$, are melted together in an iron pot; when in complete fusion a little oxide of iron is added. The

mixture is applied hot, the first coat being allowed to become dry before the second coat is added.

The Builders' Iron Foundry, of Providence, R. I., has shipped to Chicago a 36-in. Venturi meter, manufactured under the patents of Clemens Herschel, C.E., New York City. This meter will be placed in the extreme southeast corner of the grounds, and will measure the entire water supply of the Columbian Exposition (about 24,000,000 galls. a day). The recording apparatus will be exhibited in the adjacent building of the sewage cleansing works.

Westinghouse, Church, Kerr & Company has been awarded the contract for the new power house of the Newton & Boston Street Railway, at Newtonville, Mass. The steam pressure will be 130 lbs., using Babcock & Wilcox boilers. The generator-room will contain two Westinghouse compound engines, condensing, driving Thomson-Houston multipolar generators. The original installation is for 400-H. P., and the station is to be in operation July 1.

The Chicago Forge & Bolt Company, 40th Street and Stewart Avenue, Chicago, have recently leased to Pittsburgh parties the old rolling mill which was operated by the Straight Fiber Iron Company until its destruction by fire some six or seven years ago. The new company, who will operate under the name of the Chicago Rolling Mill Company, are refitting the plant with new machinery and preparing to commence active operations in the manufacture of iron at an early date.

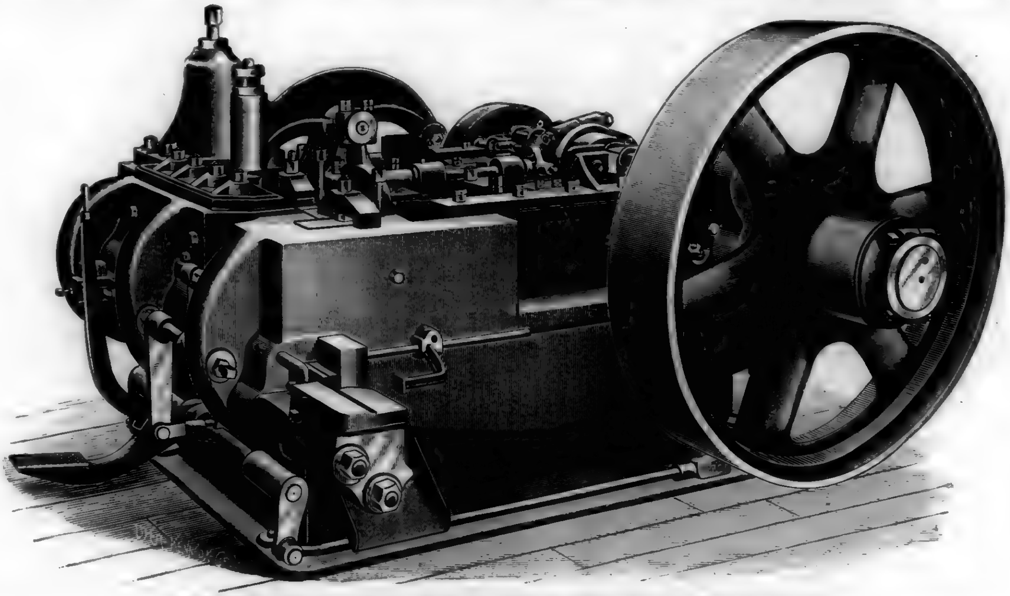
The Joseph Dixon Crucible Company have been offering for several months past to send a pamphlet descriptive of the nature and peculiarities of graphite, with a scientific opinion of its value as a lubricant, together with the experience of practical engineers and machinists. This offer has been very widely accepted, and they now offer to send a sample of Dixon's pure type Ticonderoga flake graphite free of charge, with a pamphlet, to any who will write for it. They say in their circular that every one who has any use for a lubricant should make themselves thoroughly posted in regard to one which possesses such peculiar properties, and should avail himself of a chance to see a sample and learn of its many uses.

The Lake Erie Engineering Works have just completed the machine work on two barbettes for the cruiser *New York*. Each of the plates is made in four parts 10½ in. thick and bent to a radius of 10 ft., making a circle 20 ft. in diameter. The four plates, when so formed into this circle, make a ring 20 ft. in diameter, 6 ft. high and 10½ in. thick, and weigh, in the rough, over 90 tons. This work was done upon a big lathe in their shop which both turned off and bored out the ring, as well as faced the edges.

Westinghouse Machine Company have been running their works for a year with a full night force. The shops are crowded with a large amount of heavy work in addition to their regular line of manufacture. There are now coming through ten 600-H. P. compound engines, of which eight are for the Philadelphia Traction Company, for direct coupling to multipolar generators, and two are to fill an order placed by E. D. Leavitt for the Calumet and Hecla mines, to be used in driving electric pumps for mine drainage. The company has just completed the shipment of six 1,000-H. P. engines for the Westinghouse Electric Company, to be used in filling its contract for lighting the World's Fair. These engines are also coupled direct to 1,000 light generators. They stand 18 ft. high and make 200 revolutions per minute.

The General Engineering Company of Wheeling, W. Va., have recently sold several of the large punching and shearing machines which we illustrate on another page. They are just now making arrangements for their removal to Harvey, Ill., where modern shops have been built which are fully equipped with modern tools, switch facilities, traveling cranes, steam-heating apparatus and electric lights. Their main building is of brick, 360 ft. × 100 ft. The auxiliary shops, such as blacksmith shop, engine and boiler rooms, pattern shop and storage buildings, are also of brick. They will continue to manufacture heavy rolling mill machinery, plate-glass machinery, steamboats, mining, wire and cut nail machinery, besides doing blast furnace work and building engines and boilers. The foundry department of the new works is already in operation.

The Laidlaw & Dunn Company, of Cincinnati, and the Gordon Pump Company, of Hamilton, O., have consolidated. The Laidlaw & Dunn Company has grown very rapidly in the last five or six years. They, shortly after organizing, bought out the business of the McGowan Pump Company, a very old concern, and later bought the plant of the Eclipse Pump Manufacturing Company, and now their consolidation with the Gordon Pump Company will make one of the largest concerns in the country. The new company will incorporate under the name of The Laidlaw-Dunn-Gordon Company, with a capital stock of $700,000, $200,000 of which will be preferred stock. None of the stock will be sold to the public, but will all be taken by the present stockholders of the two companies. The Directors of the new company will be Robert Laidlaw, Walter Laidlaw, J. W. Dunn, Thomas McDougall, Thomas T. Gaff, Alexander Gordon, Robert C. McKinney, the first five being of Cincinnati, and the last two of Hamilton, O. The officers of the new concern will be Robert Laidlaw as President, Walter Laidlaw as Vice-President and General Manager, and J. W. Dunn as Secretary and Treasurer. A new factory will soon be built, probably at Cincinnati.



IMPROVED BOLT HEADING MACHINE, BUILT BY THE ACME MACHINE COMPANY.

LOCOMOTIVE RETURNS FOR THE MONTH OF JANUARY, 1893.

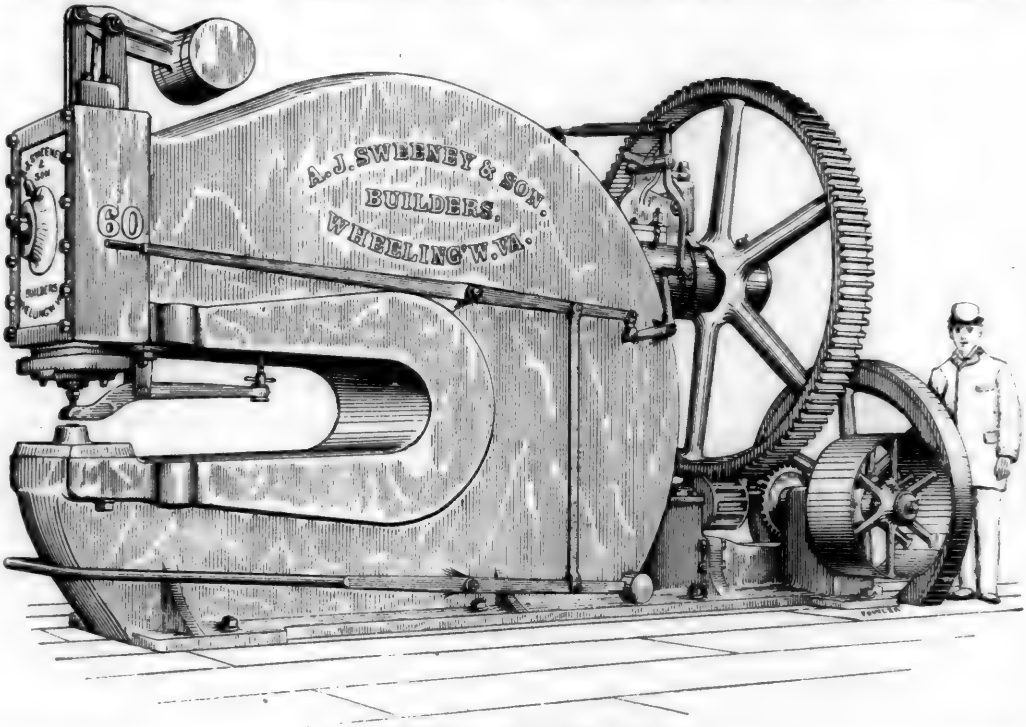
Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage.					Av. Train.		Coal Burned per Mile.						Cost per Locomotive Mile.							Cost per Car Mile.		Cost of Coal per Ton.
			Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Passenger Cars.	Freight Cars.	Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Passenger.	Freight.	
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Alabama, Great Southern																									
Alabama & Vicksburg																									
Atchison, Topeka & Santa Fé																									
Canadian Pacific	611		475,216	677,672	381,476	1,534,364	2,511						80.12			4.50	13.68	0.45		5.76	1.53	25.92			3.82
Chic., Burlington & Quincy			523	1,605			3,568						98.52			4.52	6.93	0.26	0.44	6.90		19.03			1.41
Chic., Milwaukee & St. Paul	620					2,710,814							80.02			4.57	8.39	0.28		6.85		20.09			2.05
Chic., Rock Island & Pacific	552		559,330	965,662	431,001	1,955,993	3,543						72.43			2.93	7.07	0.25	2.03	5.90	0.44	26.95			2.70
Chicago & Northwestern	868		695,922	1,438,101	701,567	2,835,590	3,193						94.20			3.99	9.80	0.38		6.38	0.92	20.97			
Cincinnati Southern																									
Cumberland & Penn*		24	5,319	34,577		39,896	1,662						94.24			9.06	5.12	0.30			1.87	16.44			
Delaware, Lackawanna & W. Main L.																									
Morris & Essex Division	156		168,868	153,844	108,226	431,038	2,729						71.58			3.55	11.22	0.39		6.46		21.64			3.10
Hannibal & St. Joseph	75					262,063	3,744						97.13			8.23		0.15	0.87	6.90		23.40			
Kansas City, F. S. & Memphis	148		103,988	295,571	129,749	529,308	3,577						70.94			2.98	5.75	0.28	0.43	7.38		16.82			1.57
Kan. City, Mem. & Birm	41	36	36,358	62,065	12,208	110,631	3,073						78.58			3.52	3.92	0.24	0.41	7.00		15.09			1.03
Kan. City, St. Jo. & Council Bluffs	39	36	60,551	40,094	42,624	143,269	3,770						72.18			4.14	6.96	0.16	0.36	5.97		17.50			
Lake Shore & Mich. Southern	590		448,627	924,967	530,969	1,904,563	3,211			77.08	96.12	40.25	76.54					0.08		7.16	0.17	7.39			1.54
Louisville & Nashville		345	435,104	804,215	409,658	1,647,977	4,776	5.02	15.76	68.65	120.79	54.17	89.65	13.72	7.42	4.27	7.06	0.26	1.64	6.14	0.60	19.97	3.41	1.56	1.58
Manhattan Elevated		292	774,412		60,398	834,810	2,858						51.41			2.50	10.10		0.30	9.00		21.90			3.92
Mexican Central	146	115				434,901	3,781						80.61			4.54	17.87	0.46	0.22	5.06	0.80	28.95			5.43
Mil., L. S. & Western	112		76,727	132,040	80,352	289,119	2,581						87.95			2.91	12.50	0.23		6.36	0.94	22.94			2.80
Minn., St. Paul & Sault Ste. Marie			62,129	194,148	35,747	292,024		4.40	14.47				101.21			5.33	16.59	0.28		7.09		29.29			3.27
Missouri Pacific	339	301				1,139,269	3,785	4.42	15.81	70.73	120.04		98.18			6.45	7.47	0.34	1.33	6.62	1.56	23.76	4.54	1.86	1.50
Mobile & Ohio																									
N. O. and Northeastern																									
N. Y., Lake Erie & Western	610		459,896	944,456	285,920	1,690,274	2,770	4.40	19.40	95.80	142.10	182.40				4.87	8.47	0.39	2.80	7.48	1.20	24.71			
N. Y., Pennsylvania & Ohio	259		134,422	432,343	144,772	711,537	2,747	5.30	16.10							4.67	6.65	0.32	2.36	6.93	1.13	22.06			
Norfolk & Western, Gen. East. Div.†			115,649	237,500	54,884	408,033	2,534	4.60	19.20	53.10	123.40			11.50	6.90	5.90	3.80	0.70				10.40	11.50	6.90	
General Western Division†			105,342	253,488	43,417	402,247	2,623	5.47	14.31	90.00	141.00		150.65	16.56	9.99	11.09	4.64	0.73				16.45			
Ohio and Mississippi	121		146,040	197,086	92,354	435,480	3,599						93.72			2.92	4.53	0.22	0.35	5.40	1.44	14.86			.82
Old Colony		298	335,700	135,437	127,704	598,841	2,625						66.77			3.47	12.52	0.63		6.79	0.80	24.20			3.75
Philadelphia & Reading			467,834	335,223	1,034,981	1,848,038							78.89			4.82	7.81	0.30		5.99	0.39	19.31			
Southern Pacific, Pacific System																									
Union Pacific	991		714,275	1,368,961	513,795	2,597,031	2,620	5.46	16.[illegible]				101.31			7.01	9.55	0.43	1.00	8.06	1.17	27.22	4.68	2.10	1.86
Vicksburg, S. & P.																									
Wabash	426	361	416,091	751,604	290,035	1,457,730	4,086						90.90			3.77	5.21	0.32		6.35	0.85	16.50	2.90	1.30	1.10
Wisconsin Central	149	116	123,557	212,039	57,934	393,530	2,641						94.29			4.48	11.47	0.26		7.35		23.48			2.45

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

Riehle Brothers' Testing Machine Company, Philadelphia, report the following very recent orders: American Telephone & Telegraph Company, New York, one 30,000-lb. vertical screw power testing machine; Syracuse Water Board, Syracuse, N. Y., one Riehle United States Standard 1,000-lb. cement testing machine, complete, with molds, sieves, mixing table and special appliances; Metropolitan West Side Elevated Railroad Company, Chicago, Ill., one 1,000-lb. United States Standard cement testing machine, with worm gear, rubber-pointed grips, and many sundry appliances; Leland Stanford, Jr., University, Palo Alto, Cal., one 20,000-lb. vertical screw power testing machine, with indicator; Chicago, St. Paul, Minneapolis & Omaha Railroad Company, St. Paul, Minn., one 150,000 lb. screw power testing machine, with Vernier poise, beam and tools for tensile, compression and transverse strains; Maine State College, Orono, Me., one 60,000-lb. vertical screw power testing machine, complete; University of California, Berkeley, Cal., one 5,000-lb. transverse testing machine with indicator for elastic limit; Madison Car Company, Indianapolis, Ind., one 20,000-lb. horizontal screw power testing machine; L. Hilgartner & Son, Baltimore, Md., one marble basin hole cutter; A. Plamondon Manufacturing Company, Chicago, Ill., one 3,000 lb. transverse testing machine with indicator; Gillett-Hertzog Manufacturing Company, Minneapolis, Minn., one 5,000-lb. transverse testing machine, with indicator for testing specimens 48 in. long, and other smaller orders.



60-INCH PUNCHING AND SHEARING MACHINE.

A 60-IN. PUNCHING AND SHEARING MACHINE.

We give a perspective view of a heavy 60-in. punching and shearing machine that is made by the General Engineering Company, successors to A. J. Sweeney & Company, of Harvey, Ill. The machine has a depth of throat of 61 in., and is built to punch a 6-in. hole through ¾-in. steel plate, and on an actual test punched a 6-in. hole through 1¼ in. steel. The stripper in the throat is adjustable so as to strip thick or thin plates as soon as the holes are punched, without lifting the plate too far off the die, thus obviating the danger of injuring it in falling.

The sliding head is operated by means of a cast steel cam pintle, with large wearing surfaces, and the cam pintle is so constructed as to give little or no wear. The sliding head is carefully scraped to a true bearing, and has a gun-metal gib to adjust what little wear there is to head through long service.

The cam-shaft is of hammered steel, 9 in. in diameter, with large bearings all bushed with very hard gun-metal, and the cam is 1½ in. eccentric to the center of the shaft, giving the punch a 3-in. stroke. The machine is fitted with splitting shears 30 in. long, and tie bolts 3 in. in diameter are provided for the throat when the machine is used for shearing plates of very heavy thickness.

The pulleys are 30 in. diameter by 6½ in. face, and run at a speed of 192 revolutions per minute, giving 24 strokes per minute to the machine. The gear is 8 ft. 6 in. in diameter, and is geared to a shrouded pinion 8 to 1. The fly-wheel is 66 in. diameter and has 6½ in. × 6½ in. rim and elliptical shaped arms, and weighs 2,500 lbs. The pulleys are geared at right angles to pinion shaft to allow the machine to be driven direct from the line shaft. The sliding head is counterbalanced and has a heavy spring in the head connected to the stirrup to take all the jar that is occasioned by the punch or shear going through the plate.

The clutches are faced with steel and are carefully fitted so as to bring all the jaws together at once and not break by reason of only one jaw doing the work alone.

The clutch is operated with an entirely new device, which was designed expressly for this machine. This clutch is thrown in through the medium of a forked lever and a double set of springs. On the clutch is a gun-metal stop, turned and fitted accurately. This stop has one side cut away on a bevel and can be set anywhere on the clutch and held there by screws, holes for which are tapped all around the clutch. When the clutch is released by lifting the stop-pin, it makes one revolution, and the beveled side of the stop strikes the stop-pin and forces the clutch out of mesh.

The machine can be operated and started from either side by hand or foot, and the levers connect with the stop-pin and require but very slight pressure to start the machine. By this means the clutch can be set to stop at any point of the stroke, giving great advantage in being able to always have the punch stop close to the work, whether punching thin sheets or thick sheets.

The above arrangement makes a positive and perfect interlocking clutch, making an accident to the operator impossible while adjusting the punches, dies, and shears.

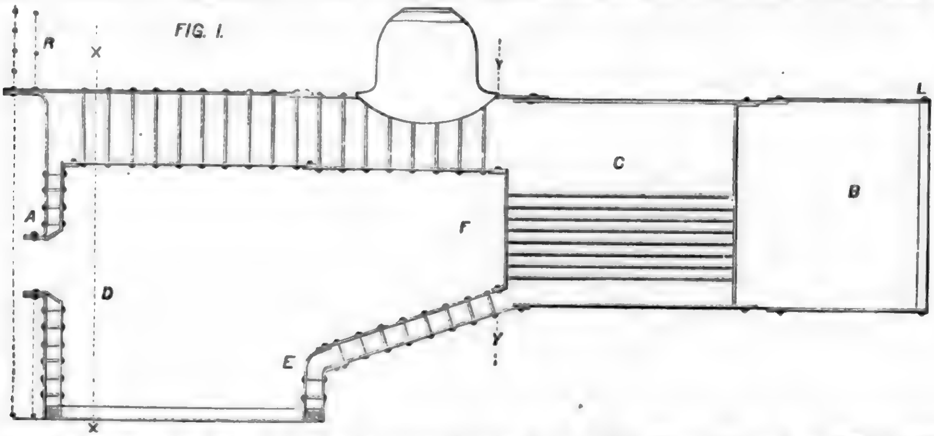
The weight of the machine is 56,000 lbs.

LOCOMOTIVE BOILER IMPROVEMENT.

J. T. Connelly, of Milton, Pa., has brought out some improvements in the construction of a locomotive boiler, which we illustrate herewith. It is intended to obviate the collection of mud or other deposits on the top of the fire-box, and of securing at the same time a greater area of heating surfaces, so that the maximum quantity of steam may be generated and the pressure maintained, while the strength and durability of the boiler is, at the same time, materially increased. In our engraving fig. 1 is a vertical longitudinal section of the boiler. Fig. 2 is a transverse section along the line *Y Y*.

Referring to the drawings, *B* designates the smoke-box, *C* the barrel, *D* the fire-box chamber, *E* the combustion chamber, and *F* the fire-box, which is preferably formed of a single sheet, and is in cross-section segmentally curved at its top and sides; from the lower edge of the latter the sheet is extended downward and parallel as shown, forming a grate space and water legs. At its forward end the fire-box is provided with an extension projecting within the barrel for about one-half the space usually occupied by the boiler flues. The extension is also formed of a single sheet, and is in cross-section circular from its rear end to about its longitudinal center, and from the latter point its contour is changed to its extreme front end, which is approximately oval. The bottom of the extension is inclined from its front end downward to its rear end, thus tending to prevent the accumulation of mud or other deposits between the inner and outer shells, and also the collection of coal or dust within. It will be further noted that by the provision of the extension and its novel shape the heating surface is greatly increased at the point where steam must be generated and maintained to give efficient service.

FIG. 1.



The advantages claimed for this form of construction are that in the usual form of construction of locomotive boilers the extreme length of the flues cause them to sag after a brief period, and the slight space between them becomes filled with mud or other deposits, impairing the efficiency of the boiler and causing what is known as "mud burning." This condition of the flues and form of construction, where the flues are in direct contact with the fire, causes as a consequence burning of the ends of the flues, and the resultant expense and danger.

Another disadvantage of the long flues is the material difficulty in cleaning the same. It may also be noted that usually in boilers of this class, by reason of the general form of construction, the inner sheets are formed with flat top surfaces, upon which mud or other deposits collect, affecting the efficiency of the boiler.

To obviate these and other objections is the purpose of this improved boiler. In its form of construction, by reason of the provision of the fire-box extension, the flues are removed from the fire and the danger of burning of the ends claimed to be obviated. By the employment of the extension the flues are shortened and rendered more rigid, thus obviating the liability to sag, and the consequent evil results. It will also be apparent that by constructing the parts of the boiler subject to the greatest pressure approximately cylindrical, and having no weak flange or sharp corners, greater strength is insured, and being without flat surfaces except the legs, back-head and throats, the accumulation of mud or other deposits is lessened or obviated.

The back-head is put in with the flange and double riveted, as shown; this is done on account of the advantages derived from the additional strength and facility of construction.

Mr. Connelly has also designed a superior lap joint, shown by fig. 3.

Heretofore in the construction of lap joints for steam boilers there have been objectionable features, which this improvement is designed to overcome, and that is that the lapped ends of the sheets not having any provision for reinforcement, places them without the line of strain when steam pressure is upon it from the inside of the boiler. This strain, which was substantially in a straight line, was found to bend the lap so as not to present a direct line of pull on the rivet, but to bend and force the rivet to assume an axial line obliquely disposed to the line of strain, which not only tended to weaken the boiler at that point, but also to uncalk the seams. The purpose of this improvement is to overcome these and other objections by providing the interior of the boiler with an inside welt, extending laterally to one side, to a width sufficient to place it immediately below the calk line, whereby it relieves the lap joint of any torsion when the calking is being done.

Another feature is to reduce the number of rivets necessary to forming such a joint, and also enabling a tight joint to be made with only one line of calking, which is advantageous

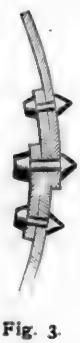


Fig. 3.

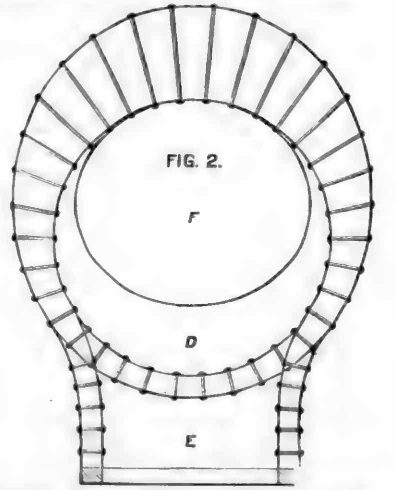


FIG. 2.

from the fact that the expense generally attending the seaming and calking is greatly reduced. These results are attained by the construction and arrangement illustrated in the drawings.

A represents a segment of a circular boiler having its ends overlapping each other, and secured to the interior is an inside welt placed so that the calking edge will be about its central longitudinal line, whereby when the sheets are subjected to the impacting process of calking the strain is taken up or absorbed by the welt.

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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NEW YORK, JUNE, 1893.

EDITORIAL NOTES.

BRIDGE construction seems to be swinging around in a circle relative to the use of the old style of draw or lift bridge, which was, we believe, the original form that was given to bridges whose continuity was of necessity interrupted. There is a folding bridge at Chicago, and a big lifting railroad bridge at New York, and recent advices describe a new bridge over the Tiber at Rome, with a folding leaf for the central span, which is 41 ft. 7 in. in length.

WHILE the compound locomotive does not seem to have met with the enthusiastic reception in this country that its projectors expected and hoped for, it still continues to hold its own in Germany. At a recent meeting of the German Association of Engineers, the Chief of the Locomotive Department of the Prussian State Railways stated that the trials of the compound locomotive indicated its superiority over the single system, in that it did more work, saved fuel, and threw fewer sparks.

ENTHUSIASM is apt to run riot. Hardly has the *Campania* broken the record for the maiden voyage before the papers are publishing glowing accounts of the new White Star vessel of 700 ft., some even say 800 ft. in length, which is to make the passage from Queenstown to New York in four days and a half. It took a good many years to drop from six and a half days to a trifle less than six, and it is not at all probable that a full day is to be knocked off in a month or two. Record breaking is done by minutes just now.

AFTER a deal of trouble and some complaining on the part of inventors of magazine arms, the War Department has decided to allow the tests to be completed without any further interference. The removal of any officer of the board has been strenuously opposed on the ground that such a move would only result in confusion. It is also reported that the coming board will be instructed to pay particular attention to an examination of the inventions of Americans, with a view to supplanting the Krag-Jorgensen weapon.

NEWS comes from Ottawa that it is proposed to run a telephone line through from Halifax to Vancouver. The wire is to be of copper, and special long-distance instruments are to be used. We can hardly believe that such a project can be seriously contemplated, because the cost would be out of all proportion to the amount of business that would be obtainable. It sounds very much like a paper scheme, although the very fact that it is mooted indicates the enormous advancement that has been made in electrical matters within the past few years.

WITHIN the past few months we have illustrated a number of new systems of electric car-lighting that have been introduced in Europe. Up to the present time expense has militated so strongly against electric lighting that it has made no progress in this country; but these electricians are a determined set, and they will keep hammering away at the problem until it is solved. The latest road to make the trial is the Central of New Jersey, which is reported to be experimenting with a car equipped with 25 incandescent lamps.

NEW phases are continually developing in the Rapid Transit movement in New York. When the franchise was offered for sale there were no bidders; then the Commission began patching up for some sort of an arrangement with the Manhattan Elevated, and just as this was about to be consummated, Mr. Starin steps in and announces that a private company is ready to build the under-ground railroad, so the Manhattan contracts are held in abeyance while the people wait to learn whether there is anything in the new deal or not. Then, after a few days of discussion, the Board sddenly yields about all that the Manhattan asked for, and the latter plays coy with the demand for a payment of five per cent on the net profits of the road.

POTENTIAL CONTRIBUTORS.

IN some respects the lot of an editor of a technical paper, like that of a policeman, "is not a happy one," and it may be that analogous causes produce their respective infelicities, for the reason that omniprevalence is often expected of the policeman and omniscience of the editor. It need hardly be said that neither policemen nor editors come up to these high expectations. Of the duties of an editor it may be said in the words of St. Paul, "that tribulation worketh patience; and patience experience; and experience hope." The tribulation which he (the editor, not St. Paul) always has with him is the providing of matter for his paper which will interest and benefit his readers. The whole field of the specialty to which it is devoted is, of course, open to him. If that field embraces the science and art of mechanical engineering and railroad topics and interests, then, of course, whatever there is of interest and value relating to these subjects may supply material for its pages. To be of interest and of value, though, the material must be new. Now, an editor has the same difficulty in being intellectually omniprevalent that the policeman has in being physically so. It is impossible, however, to be mentally ubiquitous. The current literature of engineering—and the same is true of the literature of many other sciences and arts—is now so enormously great that no one person can keep

up any kind of intimate acquaintance with it. Then the practice of engineering is, of course, very much greater than the literature. An editor, therefore, naturally looks to contributors to supply material which, without such aid, it would be impossible for him to get. In his efforts in this direction he always encounters many and diverse and perplexing difficulties and obstacles. These it is thought are much greater than they should be, and to a very great extent are the consequence of misapprehension of those who are or might be valuable contributors. It is for this reason that the adjective which forms a part of the title of this article has been employed. "Potential," according to the dictionary meaning, "existing in possibility, not in actuality," and "endowed with energy adequate to a result." What we want to indicate is that there are many persons who might contribute valuable material to a publication like this, if they only had a clearer idea of what is needed, and also—if that be possible—how little value other kinds, especially second-hand, contributions have.

A dream which nearly all editors indulge in is that of having a host of contributors scattered all over the country, or—if they are more ambitious—all over the world, who will observe interesting events as they transpire, and report them to the editorial cognizance, which will thus form a perennial stream of "copy" to keep the journalistic wheels going.

It is an alluring dream, but like that of callow publishers, whose scheme for doubling their subscription list is the simple one of inducing each existing subscriber to send in another, it won't work; at least, it works only to such a very limited extent that it destroys its beautiful mathematical completeness, and fails utterly in accomplishing the grand object sought. Publishers are, however, in many ways like beggars, especially in this, that they prefer fractions of loaves to no bread, and are grateful to old subscribers—or any one else—for any new ones. So with an editor, while the scheme outlined above may not secure a ubiquitous host of contributors, it may be possible nevertheless to enlist the services here and there of persons who are careful observers, and who are willing to take the public into their confidence. It is with the hope of "endowing with energy adequate to a result" some who are valuable contributors in "possibility" that we are writing this article. To such it is proposed to give a few suggestions, some words of encouragement, and, if possible, stimulate them to share with the public some of the results of their experience and observation.

In the first place, it may be said that every contributor may be assured that, excepting perhaps to a very few intimate friends and relatives, his own personality is of no interest whatsoever. No one cares at all what you think or what you feel, but they may have the most intense interest in what you have seen. If you are writing for a technical paper, it should be done as though you were inexistent, or, at least, that you are without personal sensations or thoughts. Facts, entities, and phenomena interest the readers of a paper, but what occurs in that pulpy substance called your brain or that ossified organ, your heart, no one cares particularly about unless it be your wife, prospective or actual, your sisters, your cousins or your aunts; and they will pretend that they care more than they really do.

It is rare that what may be called a "subjective" article —that is, to quote the dictionary meaning of this word — one "especially pertaining to or derived from one's own consciousness, in distinction from external observation," is attractive to an editor or the readers of an engineering publication. Contributors should rather aim to make their contributions "objective"—that is, to quote the dictionary again, report "that which belongs to or proceeds from the object known, and not from the subject knowing, and thus denotes what is real, in opposition to that which is ideal—what exists in nature, in contrast to what exists merely in the thought of the individual."

As an example of what we mean, if the engineer on the New York Central Railroad who, it is said, recently ran a locomotive and train at a rate of over 100 miles an hour, would write out a minute account of how his locomotive acted during this run—that is, if he would tell such things as how the fire burned, how the boiler steamed, at what point of cut-off he worked the valve-gear, how high he carried water in the boiler, whether the engine rolled much, or if such a high speed could be maintained for any length of time, and if he would report other phenomena which he doubtless did or could have observed, and of which those of us who never ran an engine so fast know nothing about, such an article would be read with very great interest by many of our readers, whereas few of them, probably, would care much to know how he felt or what he thought, or whether he had a pain in his stomach, while his engine was running at that speed. For an intelligent report of the working of his engine we would be willing to pay liberally, whereas an account of his sensations, theories, and speculations about the engine would probably go into the wastebasket.

A very common but a very fatal defect of contributors is that of writing second-hand articles. This should be shunned with as much abhorrence as a person who aims to be well dressed would avoid buying second-hand clothes. A compilation from books or papers very seldom has much value as a contribution to a paper, for the reason that it is not new. Besides, the probability always is that the editor has access to the same and better sources of information than the contributor has. Encyclopædias, books, periodicals, papers, and reports to scientific societies are the tools with which an editor works. The chances, too, are that unless you are a specialist in that line, the editor to whom you send your contribution is better read in that line than you are. Because some book or paper is new to you, don't infer that it is new to all other people. A compilation is always more or less stale. Editors all know the slouchy contributor, who submits his badly written manuscript on some important subject, which an examination proves to be only a rehash—and usually a very poor one—of what the writer gleaned from easily accessible books and papers. There is always a miniature hell in editorial offices, to which such contributions are swiftly condemned with maledictions.

To be acceptable and valuable, contributions should be original. If they are descriptions or reports or observations of actual objects or events, they will always be so; if they are compilations, they never are. There is hardly a railroad, a machine shop, a ship, or an important structure of any kind anywhere which could not supply interesting material to a technical newspaper if reported by an intelligent observer. It might be only a few lines or a paragraph, but would be interesting, nevertheless.

Many persons are deterred from sending contributions to newspapers, because the data which they have or the observations they have made seem such very slight matters as not to be worth reporting. They always hold in reserve an intention of some day doing some great thing, which will

attract much attention and do them great credit. In the meanwhile they do nothing. If such people were inclined to be useful to their fellows in many little ways, the aggregate sum of their services would probably be much greater than it will be if they wait until the opportunity arrives for them to do some great thing.

Another deterring idea which often prevents those who might be valuable contributors from becoming so, is that they imagine that whatever is said or written for publication should be put into fine words and resounding sentences. Now, as a general thing the style of a contribution to a technical paper is of very little importance. The facts are the main thing. What the editor cares most about is that these are interesting and important and are correctly stated. The proof-reader will correct the spelling if it is shaky, and straighten out the grammar if it is at all tortuous.

Contributors, therefore, should not be too much concerned about the form of their contributions, excepting—especially if they are of considerable length—that what they send should be legible. Type-written copy has much to recommend it, and the facility with which it may be read may at times lead to the acceptance of an article, whereas, if an editor had to undergo the labor of deciphering illegible manuscript, the latter might be condemned to the perdition already referred to.

In composition, as in mechanics, there is a law of conservation of force, which Herbert Spencer formulated very clearly in one of his essays,* in which he says that the law underlying some of the current maxims about composition is "the importance of *economizing the reader's or hearer's attention.* To so present ideas that they may be apprehended with the least possible mental effort is the desideratum toward which most of the rules point. . . . . Regarding language as an apparatus of symbols for conveying thought, we may say that, as in mechanical apparatus, the more simple and the better arranged its parts, the greater will be the effect produced. In either case, whatever force is absorbed by the machine is deducted from the result. A reader or listener has at each moment but a limited amount of mental power available. To recognize and interpret the symbols presented to him requires part of this power; to arrange and combine the images suggested by them requires a further part; and only that part which remains can be used for framing the thought expressed. Hence the more time and attention it takes to receive and understand each sentence, the less time and attention can be given to the contained idea, and the less vividly will that idea be conceived."

The potential contributor—for whom we have been writing—will therefore see that the general principles of mechanics are applicable to composition, and that the laws of thermodynamics have a controlling influence over words and ideas. Some one has given the general rule for composition, that the writer should know exactly what he wants to say and then say it. If he will do this so that the reader will have the least difficulty in understanding what has been written, he will be doing all that an editor of a technical paper is likely to demand.

The purpose of this article is, if possible, to induce more of our readers to note interesting observations, or observations of interesting events and phenomena, and to send them for publication. It is desirable that all imaginary barriers in the way of doing this should be removed, and that our potential contributors should feel the same, or greater, freedom in sending us information that they feel in communicating it to a friend, a cousin, or a brother. We want to divest "writing for the papers" of all formality and the greater part of the difficulties, most of which are imaginary, and to formulate a general invitation which will form a sort of a receptive vortex to draw to these pages the results of the observations of readers everywhere.

Editors, it is true, are like young women in this, that they can never part with the right of refusal, but neither of them can tell whether they will accept a contribution or a young man until it or he has been offered to them.

* The Philosophy of Style. Essays Scientific, Political and Speculative. Volume II.

CURRENT READING.

Marine Review.—This paper of May 11 blossoms out with a beautifully colored lithograph of one of the two twin-screw passenger steamships for the Northern Pacific Company, which are now building at the Globe Iron Works Company, of Cleveland, O. The paper contains 18 pages of reading matter. Besides other interesting material, an article relative to the Belleville boilers is contributed by Miers Coryell, the representative of the United States of the French owners of patents on this kind of steam generator. It should be added that these boilers have been installed in the new ships, of which our cotemporary gives an illustration. There is a general prosperous air about the pages of this last number of the *Review* which leads to an expression of congratulation.

BOOKS RECEIVED.

Knots, Splices, Hitches, Bends and Lashings, by F. R. Brainard, Ensign U. S. N. New York Practical Publishing Company.

Alternating Currents of Electricity, their Generation Measurement, Distribution, and Application. By Gisbert Kapp, C. E. The W. J. Johnston Company, Limited, New York.

Pumping Machinery. A Practical Hand-book relating to the Construction and Management of Steam Power Pumping Machines. By William M. Barr. Philadelphia, J. B. Lippincott Company.

The Coal Trade. A Compendium of Valuable Information relating to Coal Production, Prices, Transportation, etc., at Home and Abroad. By Frederick E. Saward, Editor of the *Coal Trade Journal,* New York.

Beeson's Inland Marine Directory. By Harvey C. Beeson, Detroit, Mich.

The Great Lakes Register of Shipping; also Rules and Tables of Scantlings for the Construction of Steel Ships. By Joseph R. Oldham, Cleveland, O.

Report of the United States National Museum, under the Direction of the Smithsonian Institute, for the Year ending June 30, 1890.

Annual Report of the Chief of Engineers, United States Army, to the Secretary of War, for the Year 1892. Four volumes and Atlas. Government Printing Office, Washington.

United States Geological Survey. J. W. Powell, Director. Mineral Resources of the United States, 1891. *David T. Day, Chief of Division of Mining Statistics and Technology.*

AMERICAN AND ENGLISH LOCOMOTIVES.

Our engravings this month represent the valve-gears of the two locomotives which have been the subject of this series of articles. The specifications of the American gear are very brief, and are as follows:

VALVE MOTION.

Approved shifting-link motion graduated to cut off equally at all points of the stroke. Links, sliding-blocks, plates, lifting-links, pins and eccentric-rod jaws of the best hammered iron, thoroughly case hardened.

Valve-face and steam chest seat raised above face of cylinder to allow for wear. Cylinders oiled from Nathan's No. 9 double sight lubricator placed in cab, with copper pipe under boiler lagging to steam-chest.

Valves, Richardson's balanced steam-chest valves.

Mr. Adams's specifications for the valve-gear of his engine is somewhat more full, but it will be seen is also quite brief.

VALVE MOTION.

The slide-valves are to be of the best Stone's bronze, to be made exactly as shown on drawings, and with recesses in its working face.

The valve-spindles and buckles are to be of the best Yorkshire iron, and of the dimensions shown on drawing. The spindles are to be guided by gun-metal glands and bushes through the steam-chest; the valve-spindle to be tapered where it enters the valve rod, and is to be secured by a cottar of mild Swedish steel.

The valve motion is to be of the curved link type, and the expansion links are to be hung from the center. The eccentric pulleys are to be in two parts, the smaller being of best Yorkshire iron, the larger of cylinder metal, and are to be fastened on the axle by means of keys and set screws, as shown. The eccentric straps are to be of good tough cast iron, free from honeycomb or any other defect. The throw of the eccentrics to be 6 in. The eccentric oil-cups are to be fitted with a button and spring. The eccentric rods are to be of the best Yorkshire iron, secured to the straps as shown. All the wrought-iron work is to be of best Yorkshire iron, the working parts to be well and properly case-hardened and re-cleaned up, and must be of the very best finish, and free from all marks and defects. All pins are to be of best Yorkshire iron, case-hardened, 2 in. diameter, and made to standard gauges. The motion is to be reversed by a screw-gear fixed on trailing splasher on right hand side of engine. The valve-rods are to work through cast-iron guides bolted to the motion plate.

The guides are to be bored out to fit the rods and to be made of cylinder metal, and to be provided with a lubricating box, as shown. The guides are to be heated to a high temperature and then dipped in oil.

One lubricator fixed on each side of smoke-box, with pipe leading to steam chest. One lubricator screwed into each front cover of cylinder. One oil-box and pipes, led down to top of each piston-rod, and valve spindle glands, and fixed as shown.

The principal dimensions of the two valve gears have been arranged in the following tabular form for convenience of comparison:

	American Engine.	English Engine.
Throw of eccentrics	5¼"	6"
Diameter of eccentric pulleys	16"	17"
Maximum travel of valve	5.68"	*
Outside lap of valve	1"	1"
Length of steam and exhaust ports	18"	16"
Width of steam ports	1¼"	1⅜"
" " exhaust ports	2¾"	3"

From this table it will be seen that the proportions of the two gears do not differ very materially from each other. Either should give very good results. The principal differences are in the mechanical arrangement and construction of the various parts. In the American locomotive it will be seen that the valve-seats are outside of the frames, on top of the cylinders, and are horizontal. The movement of the eccentrics must, therefore, be transmitted to the valves by means of rock-shafts. In the English engine, on the other hand, the valve-seats are between the frames and on the sides of the cylinders and stand vertical. The arguments *pro* and *con* for the English arrangement are that the steam-chests are inside of the smoke-box, and are therefore to a certain extent jacketed, or kept warm, and therefore there is less loss of heat from radiation than there is if the chests are outside. It is the same argument which was used in favor of inside instead of outside cylinders. As long ago as when Clark wrote his book on "Railway Machinery," he concluded that it was possible to protect outside cylinders as well as those inside. The same thing is doubtless true of steam-chests. It is, of course, impossible to estimate the relative loss from condensation in steam-chests which are located outside, compared with that which occurs when they are inside. If, however, the conclusion which Clarke drew from his investigations, made nearly 40 years ago, and which has been confirmed by the practice in this country during that period, then there is little or no practical economical gain from having the steam-chests inside instead of outside, because they may be equally well protected in either location. It would be very interesting if some direct experimental light could be thrown on the subject, but it would be difficult, perhaps, to make such experiments conclusive. It might be possible to take two engines, as nearly alike as possible, one with inside steam-chests and the other with outside, and place both valves so as to cover the steam-ports. Then open the throttle-valves and let them each stand under steam for 24 hours, in cold weather, and make provisions for collecting the water condensed in the steam-chests. The relative amount would be an indication of the loss of heat in each.

It is argued in favor of placing the steam-chests on the sides of the cylinders, that it is then possible to make a direct connection between the link and the valve, and also that the link may be suspended symmetrically with suspension links on each side of it, whereas if the steam-chests are outside the connection must be made by means of a rock-shaft, and the link must be suspended unsymmetrically—that is, from one side only.

Now it is admitted that a rock-shaft, or "rocker," as it is generally called, is an additional member added to the valve-gear—that is, the American gear has two rockers and their two bearings in addition to the parts in the English gear. The latter, on the other hand, has a guide for the valve-stem, and two instead of one suspension link. It is admitted, too, that the first cost of the two rockers and their bearings is somewhat greater—but not much more—than that of the two guides and two suspension links of the English engine. There is no working part about a locomotive, however, which is as easy to maintain and costs so little as a rocker. It is safe to say that in ordinary practice they are not touched, for repair, on an average, once a year. Our English brethren seem to have an undue prejudice against rockers, considering how very little trouble they give to those who use them. It is true that they sometimes, though rarely, break, but when they do something ought to break, and it then costs less to replace the rocker than it would to renew some other parts which would be broken if the rocker was not.

Let us consider how much of a friend the maligned rocker is. It enables us to put the steam-chest outside with the valve-faces horizontal. In this position the steam chests, valves, valve-stems, valve-faces, stuffing-boxes, and oilers are all much more accessible and more conveniently located for repair than they are when they are between the cylinders and inside the smoke-box. Besides the valve-seats are horizontal, in which position they retain oil much better than they do if they occupy a vertical position.

On the New York Central & Hudson River Railroad it is not unusual, if an engine comes in at 10 o'clock in the morning with leaky valves, to take them out, reface them, and have the engine ready to go out at 7 o'clock in the evening. There is not a road in the country probably which does not, in cases of emergency, face up the valves and their seats over night. Can this be done with steam-chests located as they are in most English engines?

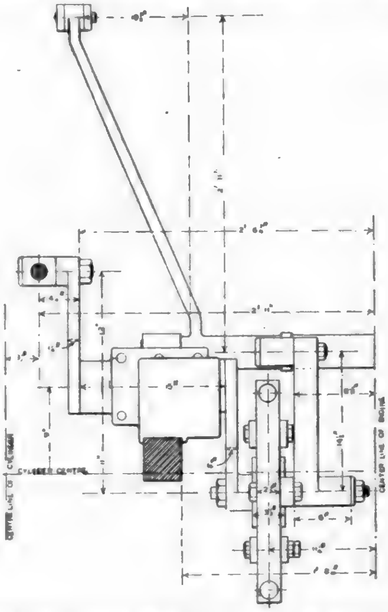
It will also be noticed that Mr. Adams's valve-yoke requires two guides, one at each end of the steam-chest. With the American form of construction only one, which forms the stuffing-box, is required. The valves of the English engine are made of bronze, which is the material generally used in Europe. Ours are universally cast iron. The extra cost of bronze and of the valve-stem guides will nearly or quite cover the extra cost of our maligned rockers.

We have no drawings of the oiling appliances for the cylinders and valves of the two engines, and cannot, therefore, form any idea of their relative cost, but from the specifications it will be seen that the valves and pistons of the American engine may be oiled from the cab by means of a Nathan sight-feed lubricator, while on the English engine the lubricators are fixed on each side of the smoke-box, and on each front cover of the cylinder. Apparently, then, there are four lubricators for oiling the valves and pistons, which require that the fireman should go to the front of the engine to apply the oil,

* As the eccentric rods are connected to the ends of the links, the travel of the valve is less than the throw of the eccentrics. Just how much this maximum travel is could not be ascertained by us excepting by an elaborate graphical construction.

whereas in the American engine one lubricator located in the cab does all the work. It is true that this is a double instrument, which is connected to each steam-chest, but it does all the work, and the lubrication can be done from the cab, without going to the front of the engine. Whether it would be practicable to oil the valves and pistons, which are located as the English valves are, with the means which are effective on our engines, we are unable to say, but if they could not be, it is thought that the slight extra cost of a pair of rockers is saved at a very considerable expense and inconvenience.

Something may also be said in favor of the method of fastening our cylinders together, which is practicable when the steam-chests are placed outside, but is not when they are inside. Cylinders for American locomotives are now almost universally cast with one-half of the intermediate saddle attached to each cylinder. To fasten them together all that is needed is to plane the surfaces of contact and bolt the two together. This makes a very stiff and rigid connection and fastening, and with suitable bolts, lugs and wedges on the frames, holds the cylinders so that they seldom work loose. It is questionable whether fastening cylinders to a plate-iron smoke-box and plate-iron frames will make as rigid and as secure connections as our method does. Our smoke-boxes consist of



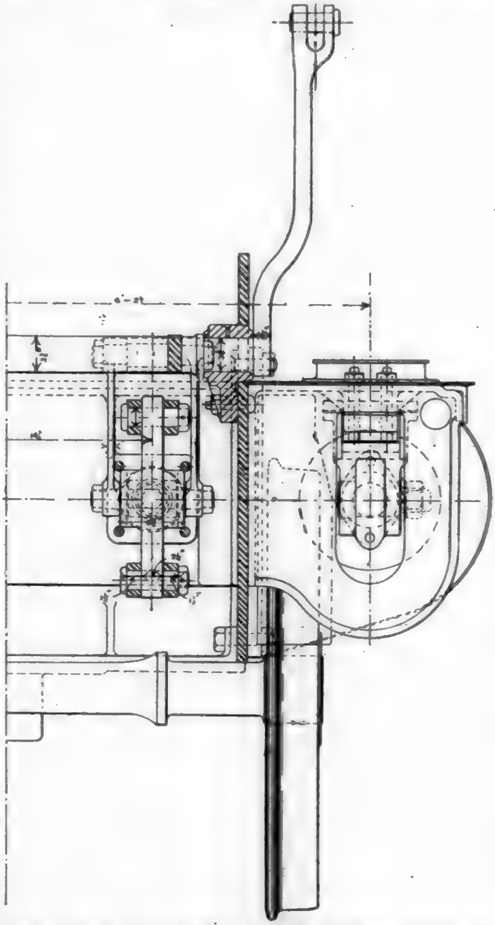
FRONT VIEW VALVE MOTION AMERICAN EXPRESS LOCOMOTIVE.

a simple plate rolled into a cylindrical form, with no flanging to it and little riveting. The English smoke-box is rectangular and is a more elaborate and costly structure, and the whole combination with the cylinders would appear to have less strength than ours.

Regarding the matter of suspending the links from each side, it will be admitted that this method satisfies a correct mechanical instinct better than the method which we are compelled to adopt when we use a rocker, and which compels us to use only one suspension link, which is attached to the inside of the link above. This gives a lop sided sort of support, and does not appear to be a good mechanical device. The bearings of the suspension link are made long and large on this account. It can be said, however, that very little practical difficulty is encountered in using this arrangement. The valve-gear of our locomotives, as it is now constructed, with ample bearing surfaces and with the balanced valves—which are now so generally used—costs very little to maintain. If the question were asked of most of our master mechanics whether they encountered any difficulties from the way the links on their engines are suspended, it is not certain that they would know what was meant by the question. The practical difficulty with this method of suspension is *nil*, which is indicated by its universal adoption on our locomotives.

It will be seen also that the eccentric-rods on the English engine are connected to the tops and bottoms of the links, instead of behind them, as is the American practice. With the former method it is impossible to lower the link so as to bring the rod opposite to the link-block. Consequently the latter and the valve stem do not get the full throw of the eccentrics. With our American links the rods can be brought up or down, so as to be opposite to the link-block, and they thus impart the full throw of the eccentrics to it. This accounts for the fact that the English eccentrics have so much more throw—6 in.—than those on the American engine, which have only 5½ in. This necessitates the use of larger eccentrics and straps, which implies more weight and increased difficulty of lubrication.

In describing the driving-wheels and axles of the English engine, we called attention to the fact that the axles were

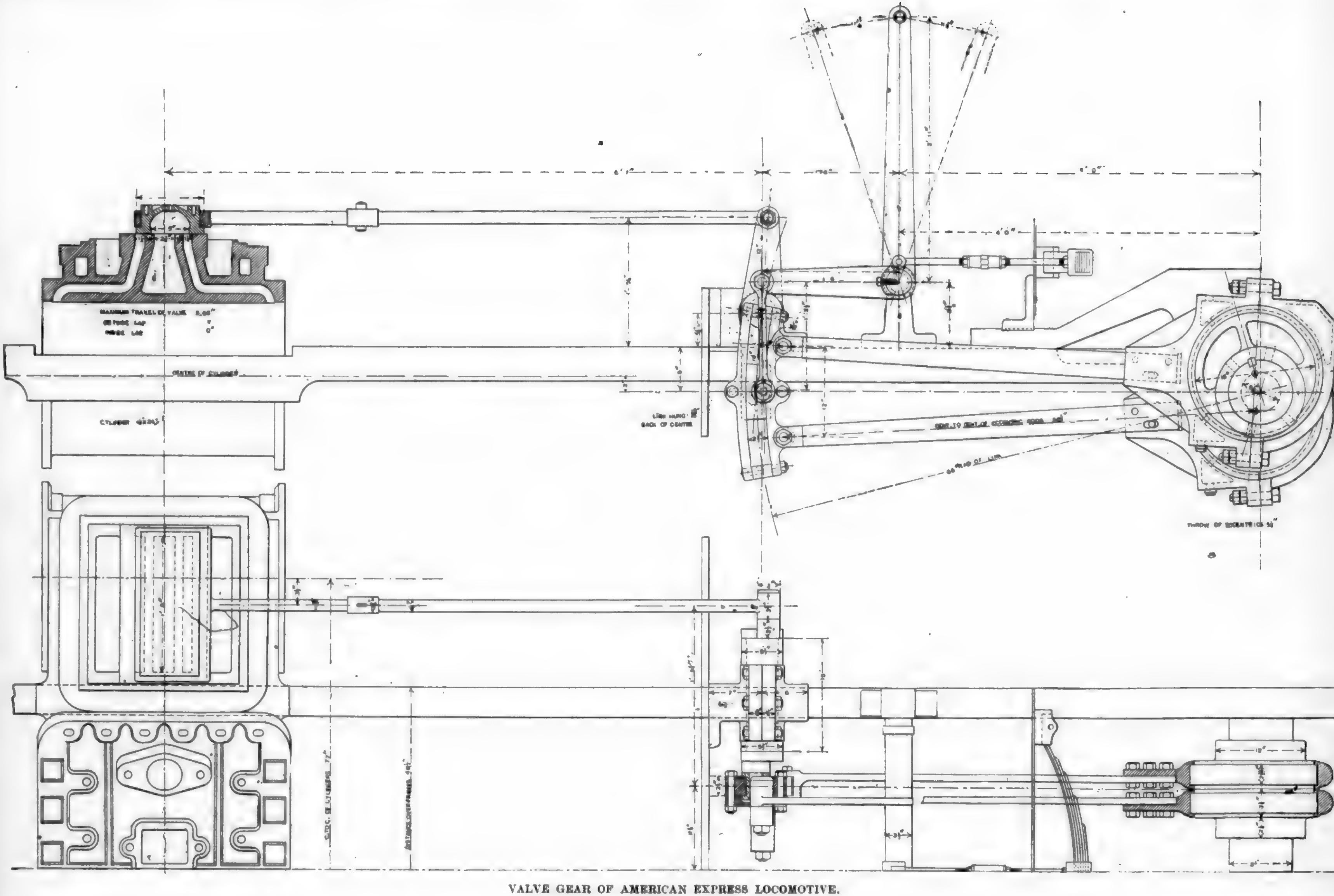


FRONT VIEW VALVE MOTION ENGLISH EXPRESS LOCOMOTIVE.

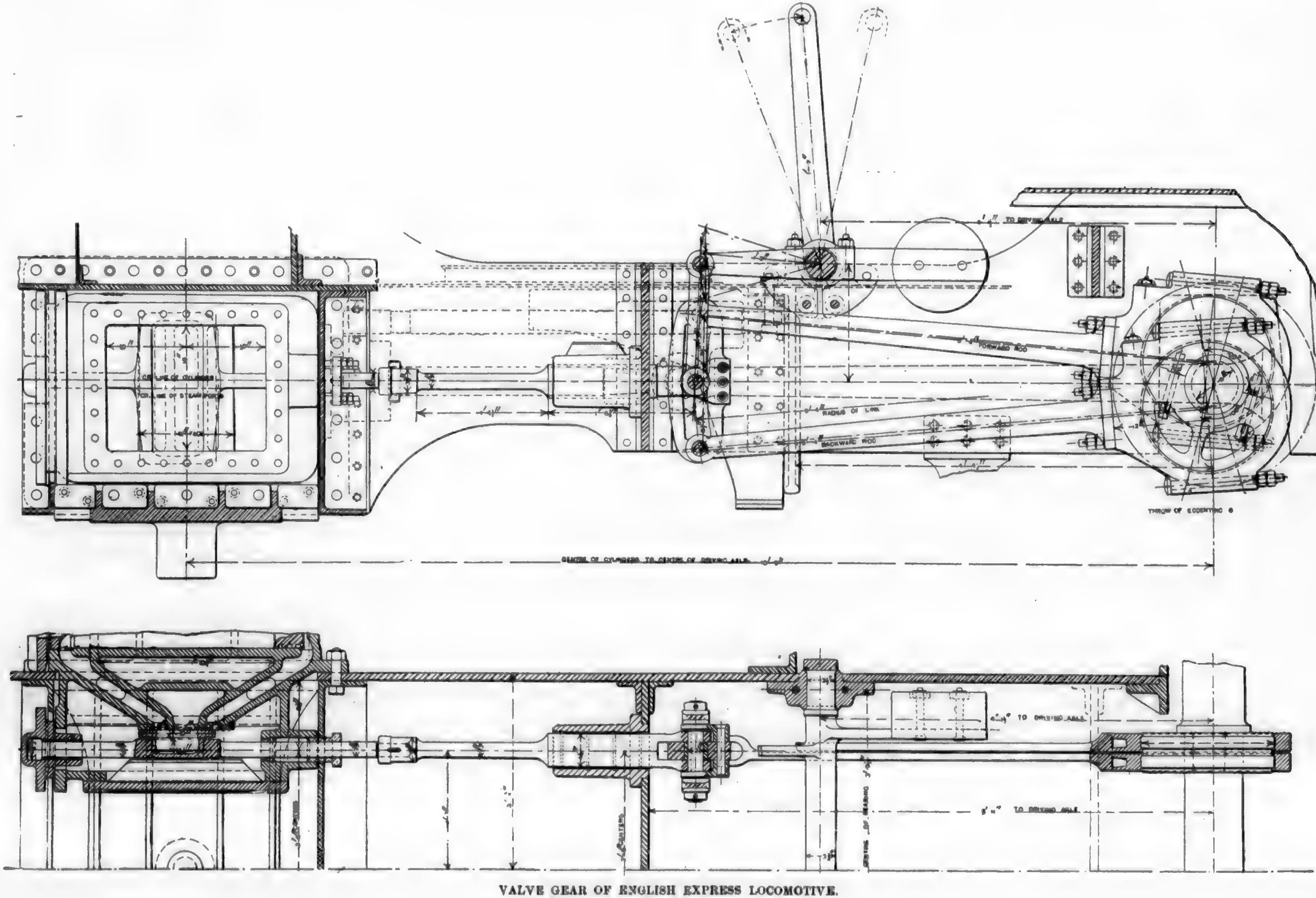
made of larger diameter in the wheel-seats than they were between the hubs. There is much to commend this practice, but from the engraving of the valve-gear and the specifications it will be seen that if this method of construction is adopted it then becomes necessary to make the eccentrics in two parts, which means greater first cost and some difficulty in maintenance.

Does the advantage of the enlarged axles pay for this?

The reverse levers are not shown in our engravings. Mr. Adams's engine has screw reversing-gear, which permits the valves to be adjusted to any point of cut-off, and lessens the labor of reversing. Mr. Buchanan's engine has the ordinary reversing lever, but with the balanced valves the labor of reversing is much diminished, and by providing a long sector with as many notches as practicable it supplies every require-



VALVE GEAR OF AMERICAN EXPRESS LOCOMOTIVE.



VALVE GEAR OF ENGLISH EXPRESS LOCOMOTIVE.

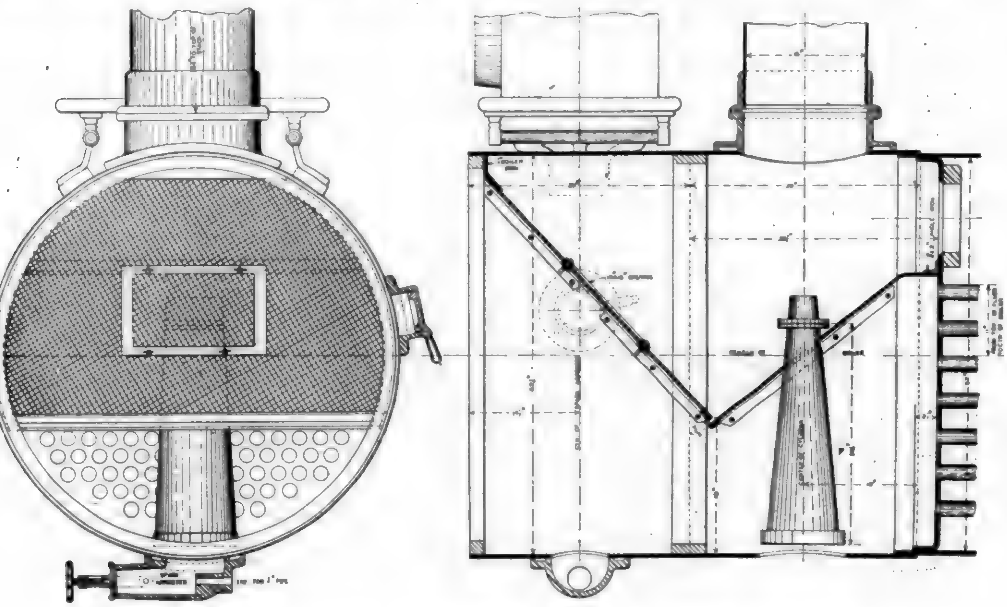
ment. The balanced valves have besides the advantage that they wear less than unbalanced valves, and require less power to move them. The algebraic sum of the advantages and disadvantages of unbalanced valves and screw reversing-gear, and balanced valves and the old-fashioned lever cannot easily be worked out on account of the difficulty of assigning values to the different elements.

The counterweights for the links are also deserving of attention. The foreign device consists of two cylindrical shaped castings each weighing 190 lbs. each. The American device consists of a light semi-elliptic spring attached to a short arm on the reverse-shaft. At least one bad accident is on record in England which was caused by such a counterweight becoming detached from an engine, and rolling under a train on an adjoining track.

IMPROVED EXTENSION FRONT, DELAWARE & HUDSON CANAL COMPANY'S RAILROAD.

The extension front herewith illustrated is one which has given very remarkable results on the engines of the Delaware & Hudson Canal Company. It was designed by Mr. R. C. Blackall, Superintendent of Motive Power of the road. The principal feature of the front and the arrangement of the deflector-plate and netting is to give an unrestricted passage from the tubes to the stack, without the interposition of anything which tends to check the draft or to confine it to any one locality along the nest of tubes.

The engraving which we give illustrates the general construction very clearly, and all of the principal dimensions are so given that it would be an easy matter to duplicate its construction. The following table gives in details some of the tests to which this extension front has been subjected, with the results there obtained :



SCHEDULE OF COAL CONSUMED BY DIFFERENT ENGINES WITH DIFFERENT DIAPHRAGMS.

No. of Engine.	Smoke Arch.	Cylinder.	Division.	Date of Test.	Points Between which Trip is Made.	No. of Miles.	No. of Train.	No. of Cars.	Schedule Time for Trip.	Coal per Trip in lbs.	Coal per Mile in lbs.	Coal per Hour in lbs.	Condition of Rail.	Remarks.	Miles per Ton of Coal.
205	Old Diaph.	19 × 24	A. & S.	Dec. 3	Troy to Binghamton.	151	1	7	7 25	10 200	67.5	1,374	Dry.	....	29.6
205	Old Diaph.	19 × 24	A. & S.	Dec. 4	Binghamton to Troy.	151	6	5	4.50	9 200	60 9	1,902	Dry.	....	32.8
202	Old Diaph	19 × 24	A. & S.	Dec. 5	Albany to Binghamton.	143	7	5	4.55	8,350	58 3	1,698	Dry.	....	34.2
302	New Diaph.	19 × 24	A. & S	Dec. 6	Albany to Binghamton.	143	7	4	4.55	4,500	31.4	912	Dry.	....	63.5
323	Pat. Austin.	18 × 24	A. & S.	Dec. 15	Troy to Binghamton.	165	3	4	5.20	6,425	38.9	1,200	Wet.	Allowing 14 miles to go to Albany Scales.	51.5
323	New Diaph.	18 × 24	A. & S.	Dec. 16	Troy to Binghamton.	165	3	4	5.20	4,900	29.6	918	Dry.	"	67.8
322	Pat. Austin.	18 × 24	A. & S.	Dec. 17	Troy to Binghamton.	165	3	5	5.20	5 500	33.3	1,026	Dry.	"	60.0
323	New Diaph.	18 × 24	A. & S.	Dec. 19	Troy to Binghamton.	165	3	4	5.20	4,850	26.3	810	Dry.	"	76.0
114	Old Diaph.	19 × 24	R. & S.	Dec. 7	Troy to Whitehall.	85	3	4	2.25	3,500	41.1	1,446	Dry.	"	48.6
113	New Diaph.	19 × 24	R. & S.	Dec. 23	Troy to Whitehall.	85	1	7	2.30	2,200	25.8	876	Dry.	"	77.2
113	New Diaph.	19 × 24	R. & S.	Dec. 23	Whitehall to Albany.	77	4	5	2.15	2,100	27.2	930	Dry.		78.8
210	Old Diaph.	19 × 24	R. & S.	Dec. 24	Troy to Whitehall.	85	1	7	2.30	3,000	35.2	1,200	Dry.	"	56.6
210	Old Diaph.	19 × 24	R. & S.	Dec. 24	Whitehall to Albany.	77	4	5	2.15	2,500	32.4	1,110	Dry.		60.8

It may be well to call attention to a few of the figures given in this table, showing the improvements claimed to have been accomplished by the substitution of this diaphragm and front for the old arrangement, taking the two engines which made the run from Troy to Whitehall on December 7 and 23 as an example. The distance is 85 miles. Both engines had cylinders 19 in. × 24 in., No. 114 hauling three cars and making a schedule time in 2 hours 25 minutes, and burning 3,500 lbs. of coal, or 41.1 lbs. per mile. Engine No. 113, making the same trip, hauling seven cars and occupying five minutes more in the passage, burned but 2,200 lbs., or 25.8 lbs. per mile, making the number of miles run per ton of coal 48 6 miles for 114, and 77.2 miles for 113. If we reduce this coal consumption to car-miles, we find that 114 with the old front

burned 10.27 lbs. per car-mile, while 113 burned only 3.7 lbs. per car-mile. Of course this difference is not claimed to be entirely due to the diaphragm when based on car mileage, because the engine in both cases had to be hauled. This comparison is taken at haphazard as we happened to glance at the table.

It will be seen by referring to the reports of engines 202 and 302, running December 5 and 6 from Albany to Binghamton, that the difference is almost if not quite as great. The average coal per mile for the old diaphragm was 58.3 lbs., whereas, with the new it dropped to 31.4 lbs. In each of these cases the condition of rail is scheduled as being dry. Men on the road say that the front keeps itself clean, and that cylinders are thoroughly churned up and can be readily blown out at the spark-arrester without any trouble.

We regret that lack of space prevents us from illustrating more of the Delaware & Hudson appliances in this issue, but the matter will be continued in our July number, when we hope to show some more of their interesting hydraulic machinery.

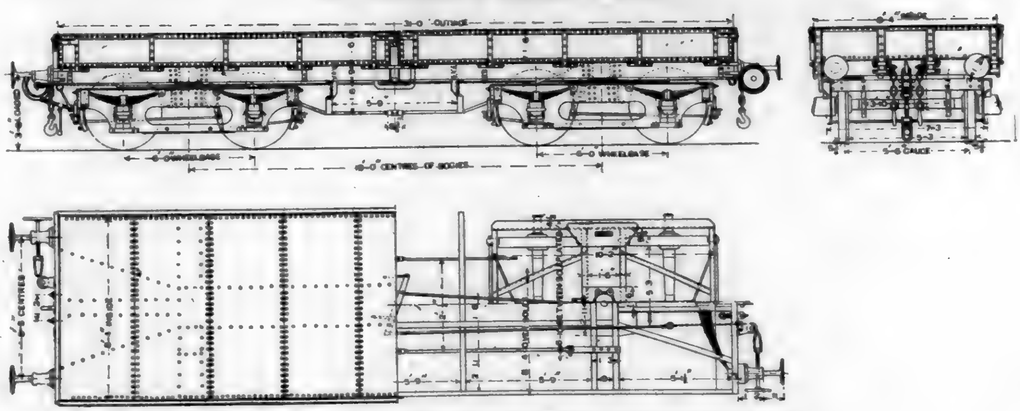
The car is trussed with two truss-rods, each $1\frac{1}{4}$ in. in diameter, taking hold of straps riveted to the body bolster, which consists of two 9-in. channels with 3-in. flanges the same as those used for the sills.

The width of body bolster over the flanges of the channels is 15 in., allowing a space of 9 in. between the two. This bolster is not trussed in any way, the strength of the car depending entirely upon the rigidity of the channels of which it is composed. The truck bolster is somewhat wider, but is composed of channels of the same size, which are spaced 18 in. apart.

The leading dimensions of the car are as follows:

Length over the buffers	35' 2"
" " body	31'
" of under frame	31'
Width inside	8' 4"
" of under frame	8' 4"
Wheel base of each truck	6'
Total wheel base	25'
Center to center of box	19'
Height of floor from rail level	3' $10\frac{1}{16}$"

CAR FOR CEYLON GOVERNMENT RAILWAYS.



ELEVATION AND PLAN OF BOGIE CAR FOR CEYLON GOVERNMENT RAILWAYS.

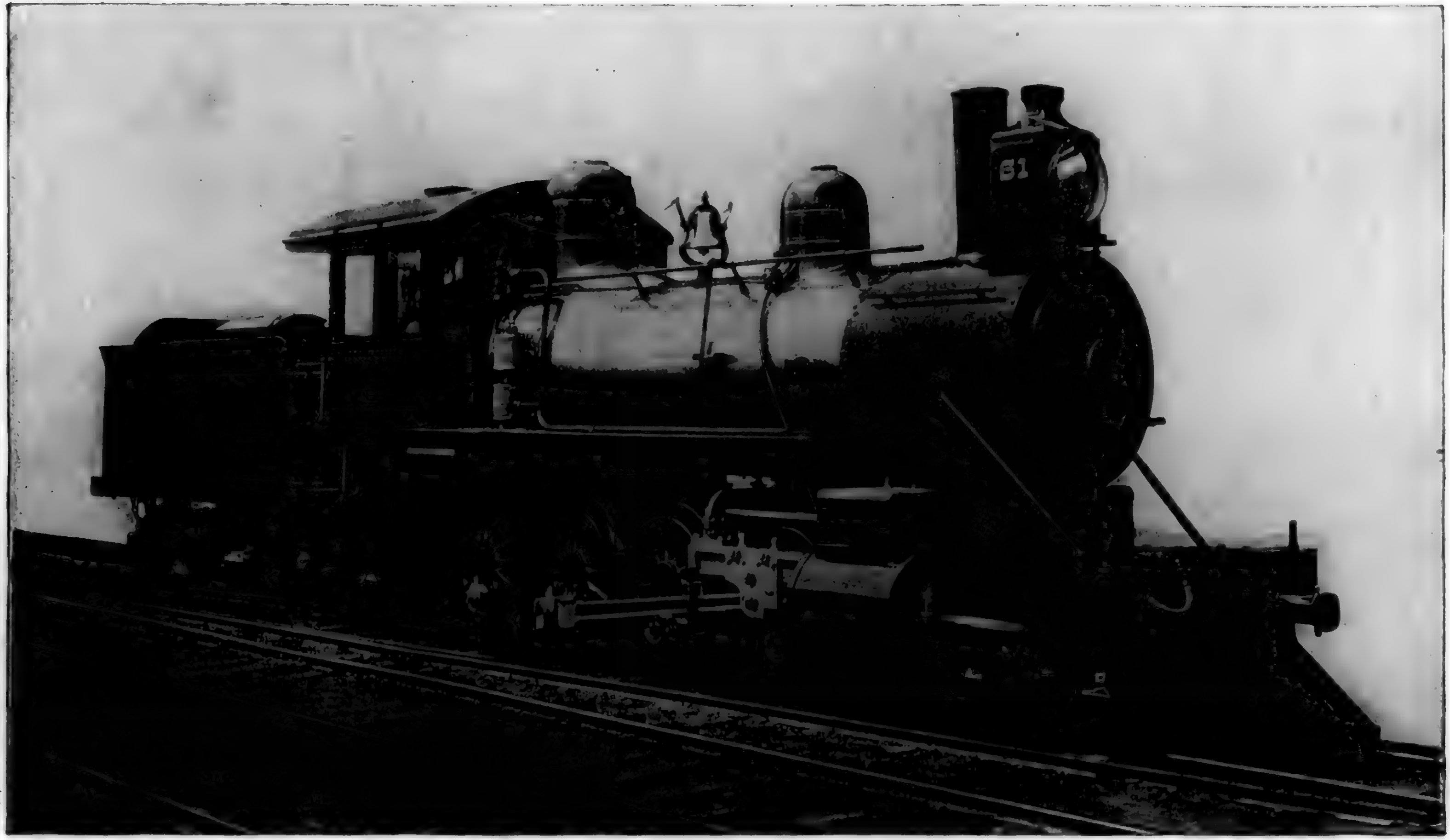
IRON FLAT CAR FOR THE CEYLON GOVERNMENT RAILWAYS.

We give a perspective view and a side elevation of a new iron car equipped with bogie trucks, which has recently been designed and built by the Lancaster Railway Carriage & Wagon Company, Lancaster, England, for the Ceylon Government railways. The truck framing is of the plate type, in accordance with the general character of English construction, and the sills are of 9-in. channels with 3-in. flanges. Of these sills there are four, the intermediate sills being spaced 16 in. apart.

Weight of under frame	7,900 lbs.
" " body	2,832 "
" " box	4,900 "
" " brake work	990 "
" " bearing springs	1,170 "
" " buffing springs	540 "
" " axle boxes	850 "
" " wheels and axles	6,834 "
Total weight of car	25,306 "

The wheels are 3 ft. 7 in. diameter on the tread, and the tires are $5\frac{3}{8}$ in. wide over the flanges, the distance between the inside of the flanges of the wheels being 5 ft. 3 in.

The brakes are applied by a hand-wheel, as shown at the side of the car which sets the brakes on the outside of each



COMPOUND CONSOLIDATION LOCOMOTIVE, BUILT BY THE SCHENECTADY LOCOMOTIVE WORKS. COLUMBIAN EXPOSITION.

wheel. The arrangement of the brake is somewhat peculiar, inasmuch as it takes the screw form, as will be seen from the plan. When the brake is turned up, the clevis is drawn back toward the outside and the brake applied.

The general construction and arrangement of the car is very clearly shown by the engravings.

ITALIAN PROGRESS IN THE TRANSPORTATION OF FREIGHT.

The Central Italian railways have introduced this year the American type of 30-ton freight cars with great success.

In commenting upon the subject, the Italian technical journal *Lavori Pubblici* says: "We have calculated the utility to be obtained by using these cars for carrying coal, basing our calculations on the quantity carried—*i.e.*, 1,152,975 tons from Genoa.

"With 12-ton cars at least 96,081 $\left(\frac{1,152,975}{12}\right)$ were employed, and as all were returned empty, and calculating the tare of each as $7\frac{1}{2}$ tons, we find that the railways have transported a dead weight of $7\frac{1}{2} \times 2 \times 96,081 = 1,441,215$ tons, which added to paying load 1,152,975 tons, shows that the railways have carried a total gross weight of 2,594,190 tons.

"If this coal had been carried by the 30-ton cars, used as above, we would have obtained the following results: $\frac{1,152,975}{30} = 38,432$ cars, the tare of which is 10 tons each, would have made the dead weight transported to and fro to have been:

$10 \times 2 \times 38,432 =$	768,640 tons.
To which add the paying load........	1,152,976 "
Results in the railway having carried..	1,921,916 "

"Therefore had these light-weight high-capacity cars been used last year carrying the same class of traffic, they would have effected a saving of the transportation of 672,575 tons. Calculating that on the Genoa line the gross weight of a train, excluding locomotive, does not exceed 300 tons, it results that the railway company would have saved $\frac{672,575}{300} = 2,261.91$ trains.

"The majority of this coal being for Milan and Turin, we will presume that these 2,262 trains would have run an average of 150 kilometers each; therefore, if a train kilometer costs the railway 3 lire for traction, we have a saving here of $2,262 \times 150 \times 3 = 1,017,900$ lire.

"This saving is in itself enormous, but to it must be added that with the 30-ton cars there would have been 86,868 less wheels and axles to care for, 57,649 less cars to register, each requiring two registrations, and an immense saving in wear, tear and lubrication, owing to the smoothness with which they run upon the tracks as compared with the rigid inflexible 4-wheeled wagons heretofore in use."

COMPOUND LOCOMOTIVE OF THE SCHENECTADY LOCOMOTIVE WORKS.

The Schenectady Locomotive Works have on exhibition at the World's Fair four locomotives—a 10-wheeled passenger engine, 12-wheeled freight, six-wheeled switcher and a consolidation compound. We give a full-page illustration, taken from a photograph of the latter.

The general design of these engines has been very fully and completely illustrated, and most of our readers are familiar with their details. The dimensions and general features of the engine which we illustrate are as follows:

Fuel	Bituminous coal.
Gauge of road	4′ 8½″
Total weight in lbs.	149,000
Weight on drivers, in lbs.	132,000
" " truck, " "	17,000
Total wheel base	21′ 7″
Driving wheel base	14′
Rigid " "	14′
Cylinders, Diameter	R. H., 22″, L. H., 32″
Piston, stroke of	26″
" horizontal thickness of	4¾″ and 5¾″
" packing, kind	Cast-iron rings.
" rod, diameter	4″
" " packing, kind	U. S. metallic.
Steam ports, size	R. H., 21 × 2⅛″ L. H., 19 × 2⅛″
Exhaust ports, size	R. H., 21 × 3″ L. H., 19 × 3″
Bridges, width	1⅛″
Slide valves, kind	Richardson balanced.
" " greatest travel	5½″
" " lap of	Outside, ¾″, inside, 0″
" " lead in full stroke	$\frac{1}{16}$″
Valve, steam packing, kind	U. S. metallic.
Driving wheels, diameter outside of tire	51″
" journals	8½″ diameter × 9″ long.
Engine truck, style	2-wheel swing bolster.
" " wheels, kind	Krupp steel tired spoke.
" " " diameter	30″
" " journals	6″ diameter × 10″ long.
Crank pin journals, main pin, main rod	6″ " × 6″ "
" " " " side "	6⅛″ " × 5⅛″ "
" " " inter " " "	5½″ " × 4½″ "
" " " front " " "	5″ " × 3⅜″ "
" " " back " " "	5″ " × 3¾″ "
Boiler, working pressure in lbs. per sq. in.	180
" style	Wagon top.
" diameter of first ring outside	62″
" thickness of steel	½″, $\frac{9}{16}$″ and ⅝″
" maker " "	Worth.
" horizontal seams	Sextuple riveted, butt joints.
" circumferential seams	Double.
Firebox, length	108$\frac{3}{16}$″
" width	41⅜″
" depth	Front, 62¾″; back, 59⅜″
" thickness of steel	Crown, ⅜″; tube, ⅝″ Sides, $\frac{5}{16}$″; back, $\frac{5}{16}$″
" maker " "	Otis.
" water space	Front, 4″; sides, 3″; back, 3″
" crown stayed by	6″ × ⅝″, crown bars.
Tubes, material	Charcoal iron.
" No. of	301
" Outside diameter and thickness	2″ O. D. × 11″ W. G.
" length, over tube sheets	12′
Heating surface, tubes in sq. ft.	1,878
" " firebox "	168.2
" " total in "	2046.2
Grate " " "	31.1
" style	Rocking.
Ash pan, style	Sectional.
Exhaust nozzles, style	Single.
" " diameter	5″, 5⅛″ and 5⅛″
Throttle	Balanced valve, double poppet
Smokestack, inside diameter	14″ near bottom.
" top above rail	14′ 5″ Eng. Central.
Boilers supplied by	2″ 10 monitor injectors.
Tender, weight empty in lbs.	35,000
" Wheels, No. of and diameter	8—33″
" " kind	Rochester cast-iron chilled plate.
" journals	4⅛″ diameter × 8″ long.
" total wheel base of	15′ 3½″
" frame, style	6½″ × ¾″ × 4″ Angle Iron S. L. W. standard ....
" truck "	4 wheel, Channel iron, center bearing F. and B. addition alside bearings on B truck, S. L. W. standard.
" tank, water capacity	4,000 galls.
" " coal "	8 tons.
Total wheel base of engine and tender	47′ 2⅛″
" length " " " "	57′ 1⅜″

PHILLIPS' FLYING MACHINE.

In our May issue we described a flying machine which has been perfected by Mr. Lawrence Hargrave, of New South Wales. We now publish four views of a flying machine recently perfected by Mr. Horatio Phillips, of Harrow, of which two show the machine in the act of flying, it being lifted from 2 ft. to 3 ft. off the ground. Our illustrations are, of course, from photographs, and it will be easily understood how difficult it is to photograph a piece of mechanism of this description, moving at so high a speed, when close to it. The aerial propeller itself is not visible, the motion being too quick, the revolutions per minute being about 600. Our illustration, fig. 1, shows the "whirling machine" which Mr. Phillips has used in the course of his numerous experiments in order to ascertain the best form of slat or sustainer, while below it the flying machine is seen at rest.

We have recently seen another aerial machine of Mr. Phillips's in operation, the same engine and boiler, however, being used. In this latter trial the weight of 72 lbs. was lifted clear of the track; but the distance which the machine flew was not so great as on the first trial we witnessed, and this in spite of the fact that the day was more favorable, there being less wind, the travel of the breeze being probably about 10 miles per hour. From this it may be argued that Mr. Phillips has not improved the first machine we saw by the modifications he has introduced. The chief alteration was an addition to the area of sustainer surface, and Mr. Phillips is of opinion that he has gone beyond the limit of the power at his disposal with the present propelling mechanism. The slats or sustainers in the last machine were also placed at a slight angle, while the first were entirely horizontal. This had the effect of reducing the speed and therefore the efficiency of the surfaces. The speed which Mr. Phillips has in view to commence with is 40 miles an hour, and in order to reach this speed lighter propelling machinery will be required. At present Mr. Phillips has turned his attention more especially to the sustainer surfaces. Although the engine is a very nice specimen of mechanical work, much might be done in lightening this part of the apparatus, especially in regard to the boiler.

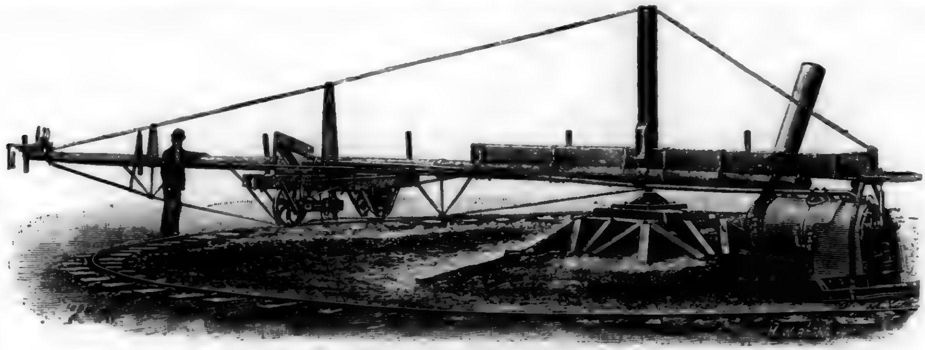


FIG. 1.—EXPERIMENTAL WHIRLING TABLE.

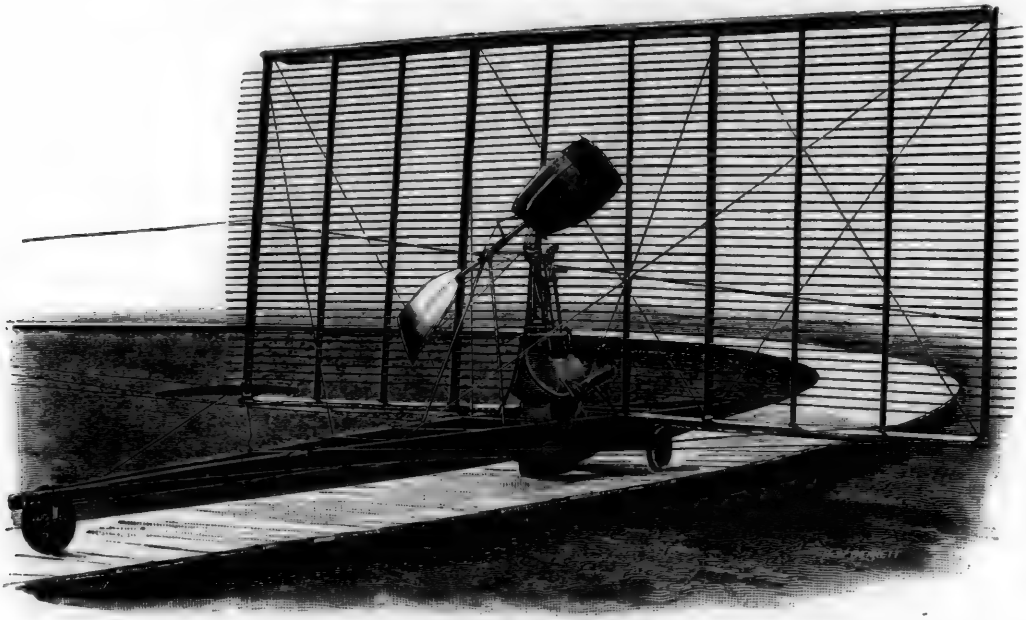


FIG. 2.—FLYING MACHINE AT REST.

FIG. 3.—MACHINE IN MOTION, FRONT VIEW.

FIG. 4.—MACHINE IN MOTION, REAR VIEW.

Mr. Phillips is now turning his attention to this part of the problem, and hopes soon to show considerably higher results. The interesting point, of course, will be reached when an apparatus large enough to carry an operator has been constructed.

Another detail to which attention has been turned is the leveling of the circular track on which the machine runs; this was known to be somewhat out of truth, but on testing it was found that there was a difference of 4 ft. 6 in. in the level of

the two sides; this has now been put right. Since our notice appeared, a large number of persons interested in these matters have paid a visit to Mr. Phillips' trial ground, and the operations are being watched with great interest by all persons connected with aeronautical matters.

A word should be said about the whirling machine. As will be seen, it consists of a spar pivoted near one end, the balance being obtained by a locomotive boiler of about 10 H. P., which is mounted on a short arm of the spar. The engine which drives the apparatus is on a two-wheeled carriage running on rails. The engine, which is attached to the long arm of the spar, not far from the pivot, runs round on a circular rail, and carries the spar with it, the steam being conveyed from the boiler to the engine by a pipe running on the spar. Beyond the carriage there projects a long arm, the end of which sweeps through a large circle; by this a rapid motion is obtained. The circle is 323 ft. in circumference, and a speed of 70 miles an hour is thus obtained. The slats or sustainer surfaces to be experimented on are, of course, placed at

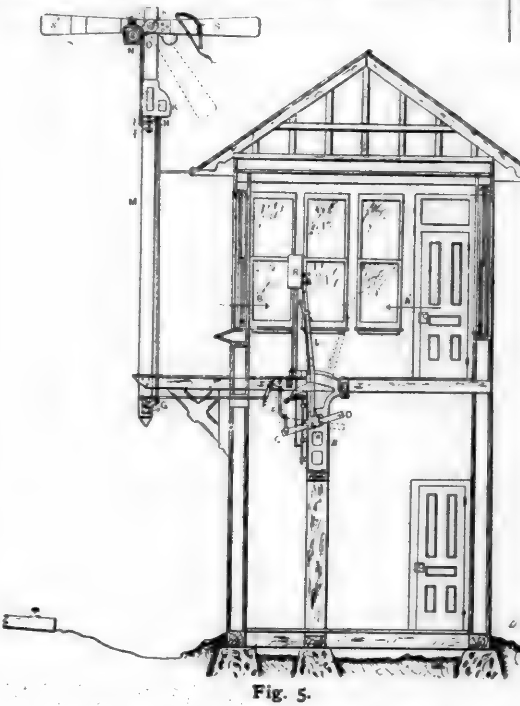


Fig. 5.

the end of the spar, and connected to an apparatus by which the weight lifted and the power required to tow the surfaces through the air are automatically registered.—*Engineering.*

PATENALL'S IMPROVED SYKES' SYSTEM OF BLOCK SIGNALS.

By the Johnson Railroad Signal Company, Rahway, N. J.

II.

The article which was published last month gave a general explanation of the principles on which the Sykes system of block signals is worked. In this one a description will be given of some of the special instruments and appliances which the Johnson Railroad Signal Company furnish for operating this system. These appliances embody not only the features which were originally brought out by Sykes, but also the improvements made by Mr. Patenall, an engineer engaged with the Johnson Company.

It should be explained here that the apparatus which was described in our first article was of a mere rudimentary type, and was illustrated merely to elucidate the general principles which are embodied in the Sykes system of block signaling.

In the article referred to it was shown how a road operated by the block system is divided into sections, with a signal station between each of them. It was also stated in that article that the apparatus illustrated therein was not shown in its true position in relation to the tracks, nor in its true proportions; some of the parts being relatively magnified in size for the purpose of representing them clearly. In the engravings which were given the locking-bar b c was shown attached to the signal-lever. In the apparatus which is now used this bar is inside of the indicator case, and controls the locking mechanism of the signal-lever by means of connections which will be described hereafter.

Figs. 5, 6, and 7 represent sectional views of a building for containing the signal apparatus of an ordinary station between two sections of a double-track road, and which also serves as a cabin or lodge* for the men who operate the signals.

Fig. 5 is a sectional view drawn on a plane transversely to the tracks. Fig. 6 is drawn longitudinally to the tracks, but looking toward them in the direction of the dart A', of fig. 5, and fig. 7 is also a longitudinal section, but looking at the signal apparatus in the direction of the dart B'.

In order to simplify the illustrations and descriptions as

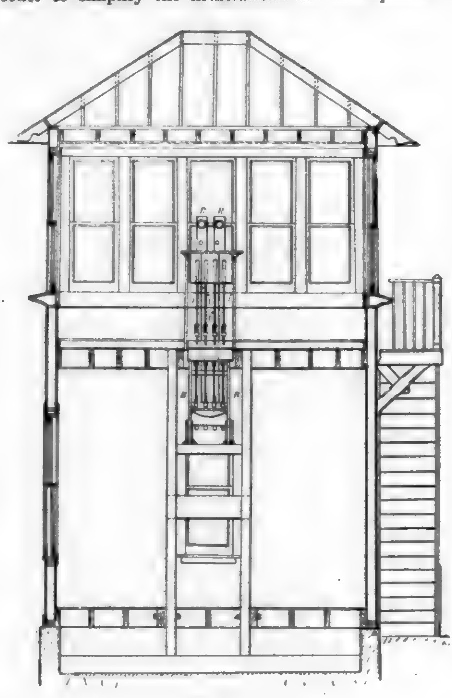


Fig. 6.

much as possible, it has been assumed that there are no turnouts, cross-overs, switches, or other complication of tracks at the station where this lodge is located, but that at the place the signals must control only the movement of trains on the two main tracks.

As shown by the engravings, structures of this kind are usually two stories in height, so that the signalmen, who occupy the upper story, can have a better view of the tracks from an elevated position than they otherwise could have.

At the station represented by the engravings the home signal post M is attached to the building, but this is a matter of convenience merely, as it may be located in any other suitable position. The post in this case supports two semaphores, S and S'. The one S, on the right side of the post, is the one which governs the trainmen in approaching the station, in the direction in which we are supposed to be looking at it in fig. 5. If we were coming in the opposite direction, and from the other side of the station, then the signal S' would, of course,

* These structures are sometimes called signal "cabins" and sometimes "towers." Neither of these terms are satisfactory. The word "lodge," which is defined by Webster as "a shelter in which one may rest," seems more appropriate.

appear on the right side of the post. It will thus be seen that the signal on the one side of the post governs the trains running in one direction, on one line of rails, and that on the other side controls the trains running in the reverse direction on the other line, and that these signals always appear on the right side of the post to the persons who must be governed by them. Besides these two signals there are also two distant signals located from 1,200 to 1,600 ft. from the signal station, as explained in the article published last month. These are not shown in figs. 5, 6 and 7, but it will be assumed that they are located in the positions designated. In order that distant signals may be readily identified, the ends of their semaphores are usually made of fish-tail form, as shown in fig. 8. Such signals are most commonly connected by wires or rods with the signal lodge, by means of which they are raised and lowered.

For operating the two home and two distant signals, four levers, *L*, *l*, *L'* and *l'*, fig. 6, are provided in the signal lodge.

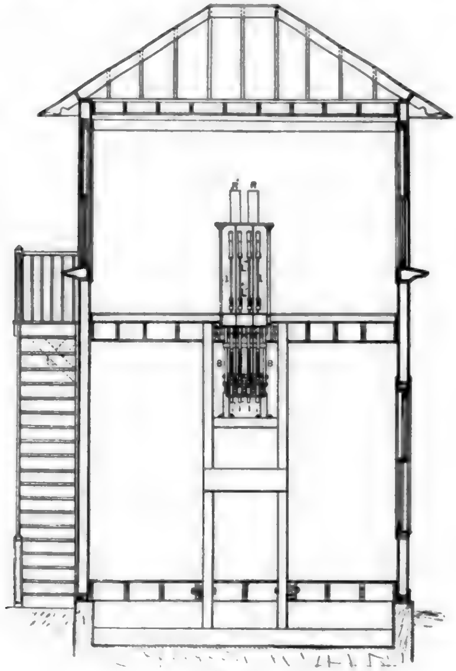


Fig. 7.

L is the lever which is connected to and operates the home signal *S*, and *l* the one for the distant signal, for, it will be assumed, the west-bound track, and *L'* and *l'* being connected with the signals which refer to the east-bound track.

The connection of the lever *L* with the semaphore *S* is clearly shown in fig. 5, *L'* being connected to *S'* in a similar way.

L is fulcrumed at *a*, fig. 6, and is connected to the semaphore *S* by mechanism, which is clearly shown and will be readily understood from the engraving. The position of the lever and that of the signal when it is lowered are shown by dotted lines, from which their operation will be apparent.

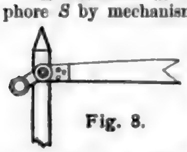


Fig. 8.

N is a lamp, and *O* is what is called a spectacle-frame, which is fastened to the shaft *h*, to which the semaphore *S* is attached. The spectacle-frame carries a red lense, *g*, which comes in front of the lamp when the semaphore *S* is raised into the position in which it is shown by full lines, and in which it indicates "DANGER." At night the red lense coming in front of the lamp shows a red light, which also indicates "DANGER." When the signal is lowered, to indicate "LINE CLEAR," the lense is raised, and the lamp then shows a white light at night.

R, *R'* are indicator cases, to which reference was made in the article published last month. *R* refers to the west-bound and *R'* to the east-bound track.

For the purpose of explaining the purpose of the apparatus employed, it will be assumed that the illustrations represent a signal station at *A*, in figs. 1, 2, 3 and 4, published last month. It will be supposed, further, that a train is approaching station *A* on the west-bound track, and that section 2 beyond *A* is clear. It was explained that "before *A* admits a train on section 2 it should be certain that there is no train on it or that it is 'clear.' If *A* depends upon information received by telegraph from *B*, there is always a chance for mistakes. They may misunderstand each other, or forget, go to sleep, or do many other things to which fallible and indolent human nature is prone. For this reason the mechanism of this system of signals is arranged so that when the signal at a station is raised to indicate 'DANGER' it is locked in that position, and the signalman at that station cannot unlock it without the co-operation or consent of the signalman at the next station ahead of him. That is, when *A's* lever and signal are in the position shown by full lines in fig. 1, *A* cannot move them until *B* unlocks *A's* lever. *B* does this by means of an electrical connection between *A* and *B*, which is operated by what is called a 'plunger,' *P'*, which is a knob or button similar to an ordinary bell-pull, which is arranged in front of

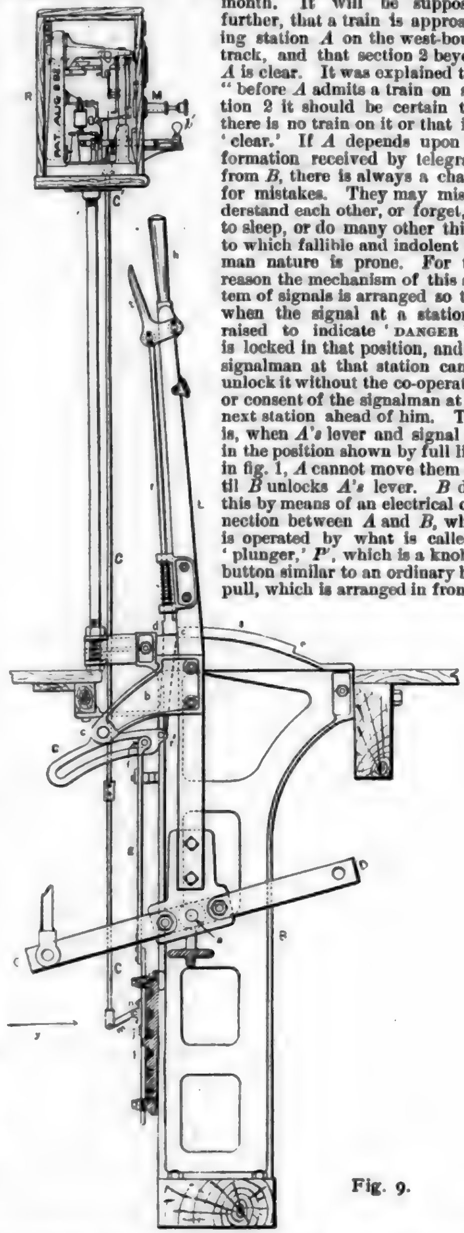


Fig. 9.

his indicator case, *I'*. The construction of this will also be explained hereafter."

We will now proceed to explain the mechanism by which *A's* signals are moved and controlled, and in the next article that by which the signalman at the next station, *B*, is enabled to control the signals at *A* will be described. Fig. 9 is an engraving showing a side view of the lever *L* of fig. 5, on an enlarged scale, so that its different parts may be seen more clearly than they are shown in fig. 5. This and the other levers are connected to an iron frame *B*, as has been explained, by a fulcrum or shaft at *a*.

The horizontal arm $C\,D$ is connected to the signal, either as shown in fig. 5, or in any other convenient way. To the lever L a bracket b, fig. 9, is bolted, which carries a slotted link, G, similar to the links used for operating locomotive valves. This link is pivotally connected to the bracket at c. The top of the lever has a hand-latch t—also similar to those used on the reverse-levers of locomotives—which is connected by a rod r to a detent d, and to the link G' at r'. s is a sector which has two notches e and e, with which the detent d engages, and thus holds the lever in either of its two extreme positions. It is clear that before the lever can be thrown back from the position in which it is shown, or toward the right, that the detent d must be raised so as to be disengaged from the notch e in the sector s.

To do this the latch t must be pressed against the handle h on the end of the lever. As already explained, the latch t is connected by the rod r to the detent d, and also to the link G' at r'. The slot of the link carries a roller f, which is attached to a rod or bar g, which in turn is attached to a vertically sliding locking-plate I. A similar locking-plate is provided for each one of the levers. This I, I', i and i' are shown in fig. 7. I is the locking-plate connected with the home signal lever for the west-bound track. This plate has a lug j—see fig. 9—riveted to it. In order to show these and some other parts more clearly, they are represented on an enlarged scale in figs. 10 and 11, fig. 10 being a similar view of these parts to that

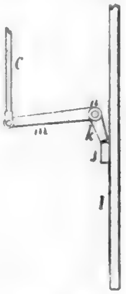


Fig. 10.

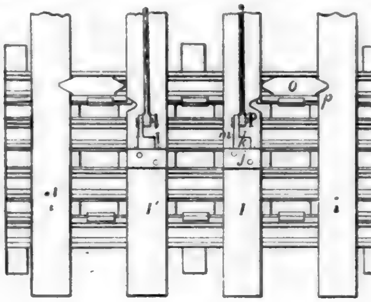


Fig. 11.

shown in fig. 9, and fig. 11 is a view looking at them in the direction of the dart y, fig. 9, or as they appear in fig. 7. Attached to the locking-frame B—see fig. 9—is a short shaft n, which has an arm or dog k, shown in figs. 10 and 11, attached to it.* This dog engages with the lug j, as shown in fig. 10. It is plain from this engraving that when the dog is engaged with the lug j that it will be impossible to raise up the locking-plate I, the bar g, fig. 9, the rod r' of the link, the detent d, the rod r, or to press the latch l against the handle H. In other words, under these conditions it will be impossible to unlock the lever by withdrawing the detent d from the notch e in the sector s. Consequently as long as these conditions exist the lever will be securely locked in the position in which it is shown. From figs. 9 and 10 it will be seen that the shaft n has an arm m attached to it. This arm is connected by a rod C, C, C', with the indicator case R.

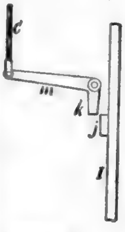


Fig. 12.

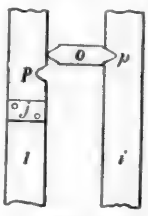


Fig. 13.

Before proceeding farther and showing how the signalman at station B, figs. 1, 2, 3 and 4, can unlock the signal in A's lodge, it will be necessary to explain the construction of the appliances in the indicator case R, by means of which this is done. The operation of the levers and signals will, however, first be explained, the description of the apparatus by which the signalman at one station controls the signals at the station behind him being reserved for another article.

Last month it was stated that the levers by which the signals are operated are arranged in such a way that *in indicating danger*, the movement of the distant signal always *precedes* that of the home signal. The reason for this is that if there is danger beyond the home signal, the distant signal should indicate it first, so that a train approaching a station may be stopped before it reaches the home signal. If a car or other obstruction or defect in the track was located immediately beyond the home signal, it might not be possible to come to a stop if this were not known until the home signal was visible. In fact, as has already been explained, the object of distant signals is for the purpose of giving engineers warning of obstructions at a sufficient distance from stations to enable them to stop before reaching the next block section which begins at the home signal.

For these reasons the levers by which the home and distant signals are operated are arranged to "interlock" with each other—that is, such mechanical appliances are provided that if the two signals are lowered to indicate LINE CLEAR, the distant signal must always be raised *first* before it is possible to raise the home signal.

If the signals are at "DANGER," then the distant signal cannot be lowered until *after* the home signal has been lowered. The reason for this is that the object of lowering the distant signal is to indicate that the line is clear not only between the distant signal and the home signal, but in the section beyond. It would obviously be a contradiction to lower the distant signal to indicate that the line is clear in the next section so long as the home signal shows that it is not. If the section ahead is clear, this should first be shown by lowering the home signal, and then the lowering of the distant signal will reiterate this indication, and also that the space between the distant and the home signals is also clear.

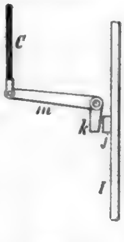


Fig. 14.

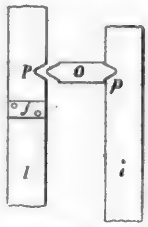


Fig. 15.

The mechanism provided for interlocking the levers is shown in figs. 9, 10 and 11. As before pointed out, figs. 10 and 11 show two views of the locking parts on an enlarged scale. It will be supposed that the signal S of fig. 5 is at danger, and the other parts are in the position shown in figs. 9, 10 and 11. If the rod C and arm m are lowered so that the dog k engages with the lug j, evidently, as has been explained, the plate I cannot be raised, and consequently the latch d, fig. 9, could not be lifted out of engagement with the notch e, and therefore the lever could not be moved. It will be noticed that the *latch* of this lever is locked and not the lever itself. In some of the earlier forms of signal apparatus the levers themselves were locked, and it was then found that the parts became worn, and that consequently the locking appliances did not always hold the levers fast, as they were intended to do. In the arrangement which is here illustrated, and which is now generally employed in the best interlocking apparatus, the signalman is not able even to commence to make any movement of signals until *after* the locking or unlocking of the levers has been completed. The rod $C\,C\,C'$, fig. 9, may under certain conditions be raised up by the signalman pulling out the handle b', fig. 9, in the indicator R. The movement of this handle is, however, controlled by the signalman at the next station ahead by means of an electrical connection between the two stations, which will be explained later. For the present it will be supposed that the rod C, dog k, and plate I are in the positions shown in figs. 10 and 11; i, fig. 11, is the locking-plate connected with the distant signal of the west-bound track. On the locking-frame, a sliding piece O is fitted between the two plates I and i, so that it can slide horizontally. Its ends are pointed so that they can fit into corresponding notches P and p in the locking-plates, when these

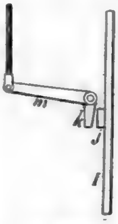


Fig. 16.

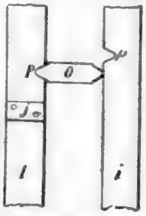


Fig. 17.

* For the sake of clearness the bearings of this shaft are omitted in figs. 10 and 11, but are shown in fig. 9.

notches come opposite to the sliding piece. When I and i are in the position shown in fig. 11, the slide O engages with the notch p in i. It is obvious that under these conditions i cannot be raised or lowered. As i is connected with the latch of the distant lever l, it is plain that with the parts in the position in which they are represented, that the signal lever will be locked. If, now, the knob b', fig. 9, was unlocked, so that the signalman at this station can pull out the knob, and he should do this, it would raise up the rod C' C and the arm m into the position shown in fig. 12, in which the dog k will be disengaged from the lug j. In fig. 13 the plates I and i are shown in the same positions in which they are shown in fig. 11—but from fig. 12 it is plain that the plate I may now be raised up, and if it is that it will release the latch of the signal lever, and the latter may then be thrown over. When the latch falls into the notch e, fig. 9, it will depress the end r' of the link G and raise its opposite end, which will lift the plate I into the position in which it is shown in figs. 14 and 15. It will be understood that this movement of the signal lever has lowered the home signal to indicate "LINE CLEAR," and that the fall of the latch has brought the plate I into the position shown in the figures last referred to—that is, the movement of the lever has been completed, and it has been relocked in its new position, and it is the movement of the latch in relocking which has brought the plate I into the position shown in figs. 14 and 15. From fig. 15 it will now be seen that the slide O is then free to move toward the left side. If an upward strain is brought on the bar i, its action on the lower inclined side of the end p of the piece O, it will tend to push O toward the left side and into the notch P. As i is connected with the latch of the signal lever, any force exerted on this latch would force the slide O out of engagement with the notch p, and thus release the plate i and the latch of the lever with which it is connected. The home signal may, therefore, then be lowered, and when the latch of its lever falls into the notch it would occupy when the signal is lowered, the plate i would be in the position shown in fig. 17, and the sliding piece O will be forced into the notch P in I, so that the home signal lever will then be locked—that is, both signals will be lowered to indicate LINE CLEAR, and the home signal lever will be locked in that position. It cannot be unlocked without throwing over the distant signal lever, lowering that signal and locking its lever, which will again bring its locking-plate i into the position shown in fig. 15. This will allow the sliding piece O to move toward the right when a force is exerted on I, which will unlock it.

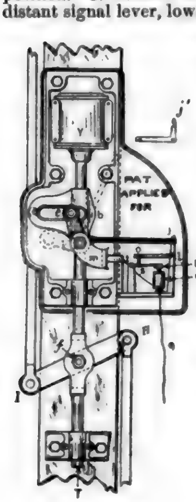


Fig. 18.

It will thus be seen that in lowering the signals to indicate "LINE CLEAR" the home signal must always be moved first, and that in restoring them to danger the distant signal must be moved first. The signals for the east-bound track are controlled in the same way by means of the locking-bars I' and i', fig. 11.

From what has been said, it will be seen that when the signals at a station are lowered to indicate "DANGER"—which is their normal position— the operator at that station cannot lower them until the signalman at the station ahead of him has released the locking-bar connected with the home signal lever. The home signal can then be lowered and afterward the distant signal. When a train has passed, or for any other reason it is desirable to raise the signals to indicate "DANGER," the distant signal must be raised first and then the home signal.

It might happen, however, that a signalman through neglect, forgetfulness, or other cause might fail to restore his signal to danger after a train has passed. To guard against this, and to insure that the home signal will always be raised after a train has passed a signal station, what is called an electric slot instrument is provided. This is shown attached to the signal post at K in fig. 5, and is represented in a larger scale in fig. 18, with the cover of its case removed, so as to show its working parts. From fig. 5 it will be seen that the horizontal arm C D of the signal lever is connected to the semaphore S by means of a rod E, a bell-crank F, a rod F G, another bell-crank G, a rod G H, a lever H I and a rod I O. The lever H I is fulcrumed at f, as shown in figs. 5 and 18. The fulcrum f is attached to a vertically sliding rod or bar, Y T, which has a slotted casting c b attached to it. e i j is a bell-crank having a fixed fulcrum at i and a pin e, which can move horizontally in the slot c b. n is an electro-magnet connected with a battery in any convenient location by a wire q, and also with a "track circuit," which will be explained later. p is an armature attached to a lever t p fulcrumed at t. o l j is a bell-crank attached to a fixed fulcrum at l. The upper end j has a hooked end shown above at j', where the bell-crank is shown detached from the other parts. This hooked end can engage with a pin on the end j of the arm i j of the larger bell-crank. The end o of the smaller bell-crank is connected to the lever t p by a short link, o s. It will be evident now that if the hooked end of the smaller bell-crank is engaged at j with the arm i j, of the larger one, that so long as the armature p is attracted by the electro-magnet n, that the smaller bell-crank o l j will be held in engagement of its hooked end with the arm i j of the larger one, and will hold the latter in the position in which it is shown so long as a current of electricity is passing through n. If the current is broken, then the armature will be released and the small bell-crank will be

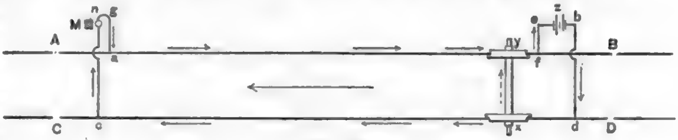


Fig. 19.

disengaged at j and release the arm i j of the larger one, and if any downward strain is exerted on its arm, e i, it will assume the position shown by dotted lines. This will allow the rod Y T to fall and the fulcrum f of the lever I H will fall with it. As the semaphore is counterweighted so as always to assume a "DANGER" position unless it is constrained to rise, the release of the fulcrum f will permit the spectacle-frame g h, fig. 5, to fall, which will raise the semaphore to indicate "DANGER."

It remains to explain the action of the "track circuit," as it is called. When this means is employed for operating signals, or as a safeguard in case the signalman fails to operate them, the rails of a short section of the track are insulated—that is, some non-conducting material is placed between the ends of the rails and between them and the fish-plates, by which the rails are connected together. Thus, in fig. 19, suppose that A B and C D represent the two rails of a track, and that these are insulated from the adjoining rails at A, B, C and D. Suppose, further, that M is a signal post, n an electro-magnet, like that shown in fig. 18, and z a battery. If one pole of the battery is connected by a wire, b d, to the rail D C, and D C is connected to the electro-magnet n by a wire, c n, and the electro-magnet is connected by a wire g a to the rail A B, and A B by a wire f e with the battery z, then the current of electricity would flow from the battery in the direction z b d c n g a f e, as indicated by the small darts. The effect of this would be to energize the magnet n, which would attract the armature p, fig. 18, which would thus hold the small bell-crank o l j in engagement with the arm i j of the large bell-crank, as has been explained, and the signal would then remain in its lowered position, if the operator should throw over his lever. Electricity, however, will always take the shortest circuit possible, and therefore if a pair of wheels, x y, of an engine or car should be rolled on to the insulated section A B C D, fig. 19, so as to place the rails A B and C D in electrical communication with each other, then the current would flow in the shorter path, z b d x y f e z, and would not pass through the electro-magnet n, fig. 18. It would, therefore, be dead and would no longer attract its armature p, which would disengage the bell-crank o l j, which would release the arm i j, and this would permit the large bell-crank to turn on its pivot i and the rod Y T to fall. This would lower the fulcrum f, which would raise the signal, as has been explained.

Y is a cylinder with a piston in it attached to the rod Y T, and intended only to provide an air-cushion to resist the too sudden fall of Y T and the consequent shock to the parts connected with it.

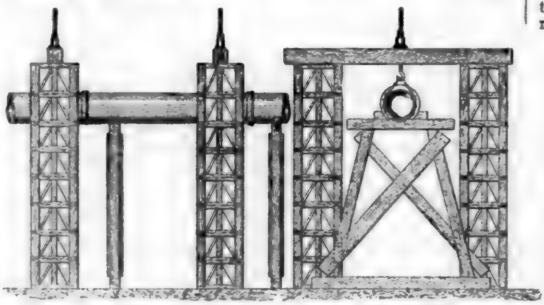
From this explanation it will be seen that, if the signalman should fail to lower his signal, after a train had passed his station, that whenever a vehicle ran on the insulated section of the track adjoining his signal, the latter would be raised automatically by the action of the wheels, and it would then be impossible to lower it so long as the insulated track is occupied.

(TO BE CONTINUED.)

AN EXPERIENCE WITH A 24-IN. GAS MAIN.

At the March meeting of the Technical Society of the Pacific Coast Mr. J. B. Crockett read a paper on An Experience with a 24-in. Gas Main, which involved not only the raising of the main, but also that of holding it with the earth subsiding all about it. The pipe was laid beneath the surface of the marsh on Santa Clara Avenue, San Francisco, Cal., for a distance of 1,424 ft. It was necessary to raise the main without cutting it or breaking it, and its success depended in a great measure on its flexibility, due to lead joints. Had the joints been of cement, as they are almost uniformly made in Eastern cities, the rigidity of the pipes and joints would, without doubt, have caused a break, or perhaps many serious breaks; but with about 100 lead joints 4¼ in. deep and ½ in. thick it became possible to raise the main without a fracture.

The first section to be raised weighed about 260,000 lbs., and the method employed in raising it was as follows: The pipe was first uncovered, the trench extending to the bottom of the main, and at intervals at 12 ft. of its entire length house mover's frames were placed on each side, one above another, to the desired height. A 12-in. × 12-in. timber was placed across these tiers of frames, passing over the pipe just behind each joint. Heavy chains were passed around the pipe, back of each heel, and what is known as a 2-in. "holder screw" was hooked to each chain and passed through a hole in the timber above. On the upper surface of the timber was an iron washer, and on this rested the large nut on the thread of the holder screw.



FIRST MANNER OF LIFTING AND SUPPORTING PIPE.

After taking up the slack on each chain, a man was detailed with a wrench to each screw, and at a signal from the foreman each man took one turn of the wrench, and the pipe was gradually raised. As the main was raised from the marsh, a gang of men was employed in blocking under it, to prevent its falling in case of the accidental breaking of any part of the lifting machinery, until finally, when it was raised to the desired height, or about 3 ft. below the official grade of the street, the pipe was temporarily supported by house frames. Seven hundred and eighty of these frames, each 2½ ft. high, were used in raising and supporting the pipe.

The next step was the permanent support of the pipe previous to the filling of the street. This was done by constructing a series of wooden trestles, 5 ft. wide at the top and 12 ft. wide at the bottom. They were made of 8-in. × 8-in. uprights with a sill underneath, and a cap at the top of the same dimensions, and braced diagonally by pieces 2 in. × 10 in. on each side. After the completion of the trestles, all the other supports, including the house frames used for raising, were removed, and apparently nothing remained to be done but to fill in the street with solid filling. The pipe had been raised without accident of any kind, all the joints had been recaulked where they had drawn, and the permanent supports were amply strong.

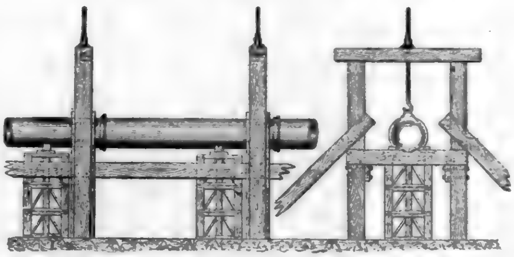
The filling of the street was commenced immediately after the pipe was raised.

As fast as the street was filled to grade, a gang of men kept the 24-in. pipe uncovered, and all went well until the fill reached the corner of Santa Clara Avenue and Arkansas Street, when, on Saturday, April 11, 1891, at 11 o'clock P.M., the northerly side of the street began to slide toward the north, carrying the pipe and its supports with it. The main settled 4 ft. and slid to the north 3 ft., and the wooden trestles were canted over in the direction of the slide.

A gang of men was immediately put to work shovelling the rock and earth away from the trestles to remove the pressure against them, and to distribute the material under the pipe. The following day a number of teams were employed to cart the material from the face of the dump, and to spread it along the line of the pipe, under and on each side of it. The object in thus carting the rock was to distribute evenly the load on the marsh, and gradually raise the whole street to the level of the pipe, instead of keeping up to the street grade, and presenting a steep face at the dump. Carting rock was continued until we had filled in solid under the pipe and had built a cartway about 9 ft. wide on each side of the pipe, level with the bottom of it. This required the handling of 5,000 loads of stone. As the stone was hauled ahead and loaded on the marsh, the street continued to settle, carrying the pipe with it

Four days after this first trouble the crossing of Arkansas Street commenced to settle very rapidly, and in 15 minutes the street had gone down 4 ft. The large body of rock settling in the mud raised the surface of the marsh at a point about 100 ft. north of the street, about 5 ft. high, and opened a crevice a foot wide. This was a natural consequence of the displacement of mud by the heavy fill of stone, but why over half of the filled street should slide bodily toward the north, at the same time, and where and when it would bring up were perplexing questions. To ascertain the exact nature of the underlying strata of the marsh, and solve at least one of these problems, we caused soundings to be made in lines 96 ft. long, extending from south to north, at right angles to the pipe, by driving a ½-in. iron bar into the ground. The crust of the marsh was found to be fairly firm to a depth of 3 ft., consisting of a sort of marl.

At the northerly side of the street, after passing through the crust, the bar sank into 19 ft. of soft mud, and then reached hard bottom. At the middle of the street the bar went down through 7 ft. of the same mud, while on the south side there were but 2 ft. and 6 in. of the mud under the crust of the marsh. The stratum underlying this mud was an extremely hard clay.



SECOND MANNER OF LIFTING AND SUPPORTING PIPE.

These soundings explained to my satisfaction the cause of the body of rock sliding toward the north. The surface of the marsh was nearly level, but the thick body of soft alluvial mud was resting on a subterranean side hill of hard clay, sloping toward the north with a trend of 14°, and as the rock fill sank into the mud it slid, mud and all, down the slope of the hard bottom.

The soundings also explained the sudden and spasmodic settling of the fill. The 3 ft. of firm crust over the marsh offered a resistance to the load of rock piled upon it, until the load was sufficient to overcome the resistance, when the crust broke, letting the entire fill settle from 4 ft. to 5 ft. at a time.

After the second settling of the pipe it was necessary to resort again to the house frames for raising it, as the wooden trestles had sunk into the marsh and were almost useless. After raising the pipe with screws to the proper height, jack-screws were used for forcing it laterally toward the south, back into its proper line. By continuous wedging under the pipe, using in all about 10 cart loads of wooden wedges, we arranged to keep the pipe in its place until May 1, when another settlement occurred, opening long fissures in the fill, and raising the surface of the marsh to the north about 9 ft., and at the same time opening several long cracks nearly 2 ft. wide. This was the most trying period of the whole undertaking, and as a safeguard I laid a line of 20-in. pipe on the surface of the marsh, south of Santa Clara Avenue, and cut the 24-in. pipe between Missouri and Arkansas streets and at Carolina Street, and put in *T*'s 24 × 20.

This was done so that in the event of the destruction of the 24-in. main, we could, by making short connections with the 20-in. main, provide a way to deliver gas to the city temporarily. Fortunately, however, this new line was never used, but its presence was a source of relief.

The last serious settlement occurred on May 15, 1891, when 12-in. × 12-in. timbers, 30 ft. long, were placed under each length of pipe, back of the joints, and the end of the timber toward the north was blocked up about 2 ft. higher than the south end. With this precaution we were enabled to keep the pipe wedged up in place, although it was a constant source of worry and annoyance, until the rock fill had found a bottom on the hard clay and the street was brought to grade. At the crossing of Arkansas Street, which was the worst part of the marsh, the main was raised at the beginning 16 ft., and the sum of all the settlement at that point was 14 ft.—that is, the entire fill settled into the marsh a distance of 14 ft., so that it was necessary to raise the pipe in all 30 ft., to maintain it at the 16-ft. level.

The contractor continued filling in until July 31, 1891, and the average amount of material dumped each day, from May 1 to July 31, was 23 train loads of nine cars each, or about 207 cub. yds. per day. As the contractor completed filling the street to grade, the pipe was kept uncovered, and a 12-in. × 12-in. timber was placed across each length of pipe, resting on blocking and wedges, chains were passed around the pipe and holder screws were used for sustaining it. For months it was necessary to keep careful watch of the pipe, and men patrolled its entire length day and night, driving wedges and taking up the slack on the chains, wherever needed. In fact, during all this time Santa Clara Avenue became one of the Company's telephone stations, and for a while was the one most frequently used

Finally, in November, 1891, the street had stopped settling, the timbers and screws were removed, and after carefully tamping the earth under the pipe, the trench was filled. Early in October, 1891, notice was received of the intention to grade Santa Clara Avenue west from Carolina Street, and as the 24-in. main extended west as far as De Haro Street (304 ft.), it was necessary to raise it out of the marsh. At De Haro Street the pipe turns at a right angle, and extends to Center Street (510 ft.), and it was necessary to raise the entire 814 ft. an average of about 8 ft. in height.

A pile structure was built to raise and sustain the pipe. Sixteen-in. piles, 50 ft. long, were driven through the marsh into the hard clay bottom. These piles were spaced 12 ft. apart, and were 5 ft. from the pipe on each side. Ten ft. outside of each standard pile a brace pile was driven and sawed off 2 ft. from the ground. On each side of the standard piles, extending down to the brace piles, were diagonal braces 4 in. × 12 in. Caps 12 in. × 12 in. were placed over the main, resting on the top of the standard piles, and a screw passed through a hole in the middle of each cap. The pipe was raised as before described.

When the pipe reached the proper grade, waling pieces 4 in. × 12 in. were bolted on the inside face of the standard piles, and across these were placed two planks 4 in. × 12 in., on edge, resting on the waling pieces and bolted through the piles. The pipe rested on these 4 in. × 12 in. cross pieces, and was prevented from rolling by pieces of 4 in. × 4 in. The entire wooden structure was securely bolted together.

The standard piles were for raising and permanently supporting the pipe, and the brace piles and the diagonal braces were to withstand any side thrust caused by sliding of the marsh.

One of the difficult features of this piece of work was the bracing of the right angle in the main, at the corner of Santa Clara Avenue and De Haro Street. This was accomplished by driving 10 piles around the T at the corner, and by a system of diagonal braces. To prevent the pipe from drawing apart, iron bands were bolted around it at the corner, and these bands were connected on each side by rods with turnbuckles.

After the pipe was raised and supported the 12 in. × 12 in. caps were removed and the tops of the standard piles were sawed off below the grade of the street. As the street was filled, the pile structure stood the strain of the street settling, but there was little or no lateral thrust, as the clay under the marsh was nearly level at this point, and the fill did not slide.

MANGANESE STEEL.*

[By Henry M. Howe.

(Concluded from page 239.)

Speaking roughly, we may say that water toughening increases the ductility of manganese steel some fivefold, and occasionally even tenfold; while often at the same time doubling the tensile strength.

* A lecture delivered before the Franklin Institute, February 20, 1892.

In fig. 9, I attempt to show simultaneously how the strength and ductility of manganese steel both increase as we hasten the cooling of the metal; in other words, that the faster we cool it, the stronger and more ductile we find it. Each of the several lines here drawn gives the tensile strength (as abscissa), and the elongation (as ordinate) of pieces of manganese steel cooled at different rates, but in all other respects alike. The semi circles with the letter *N* by them, as before, represent the metal in its natural or slowly cooled state; the black circles show the same properties in the suddenly cooled material, the letter *A* indicating that the metal has been cooled suddenly by a blast of air; the letter *O* that it has been cooled by plunging in oil; and the letter *W* that it has been cooled by quenching in water. Let us confine our attention to manganese steel containing from 9 per cent. to 15 per cent. of manganese.

As before, we see that the increase of elongation is much greater than that of tensile strength; in short, the sudden cooling is more markedly a toughening than a strengthening. Next, we note that, in general, the more sudden the cooling, the greater the strength and the elongation. Air cooling, the least rapid, gives the spots next above those of the natural state; oil cooling, next in order of rapidity, gives the next higher spots, while water cooling, the most rapid of all, gives in general the highest spots of all.

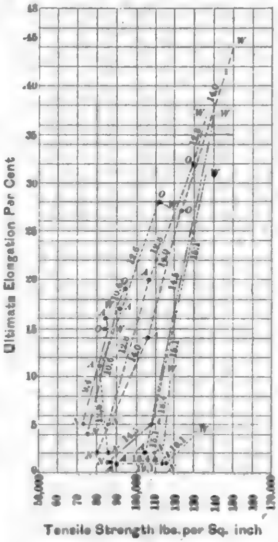


Fig. 9.

TENSILE PROPERTIES OF MANGANESE STEEL.

W = Water-toughened Manganese Steel.
O = Oil " " "
A = Air " " "
N. = Natural State.

Figures give percentage of manganese.

Next, what is truly remarkable, that in many cases these lines are nearly straight and parallel from end to end, showing that the ratio of increase of strength to increase of ductility is nearly constant for varying accelerations of the rate of cooling, and that this ratio is the same, roughly speaking, for manganese steel of different compositions. This certainly seems to indicate that the increase of strength and of ductility are, in the main, due to one and the same ulterior cause. It may be that sudden cooling prevents some change which occurs during undisturbed slow cooling, some change which requires a considerable length of time, and which weakens the metal and lessens its ductility: that at a high temperature the metal assumes a condition which, if preserved by sudden cooling, assures strength and ductility to the cooled metal; while if we cool it slowly, some slow change, decomposition, recomposition or rearrangement occurs, yielding a relatively weak and brittle substance.

But this explanation may be very far wrong, and, if it be right, we certainly do not know what the nature of the supposed change is. A change in the chemical condition of the carbon has been traced to sudden cooling; but this change does not readily explain matters. Sudden cooling changes most of the carbon of carbon steel from the "non hardening" to the "hardening" state; and the hardness and brittleness of suddenly cooled carbon steel are usually attributed to the presence of this hardening carbon. In slowly cooled manganese steel the carbon exists in both the hardening and the non-hardening state; sudden cooling increases the proportion of hardening carbon, a change which would be expected to make the metal more brittle, instead of very much more ductile as it actually becomes.

I have thus far spoken of the effect of the rate of cooling on the ductility and strength of manganese steel. But the temperature from which sudden cooling occurs also affects these properties; and in general we may say that the higher the temperature, provided it does not rise above moderate whiteness, from which the metal is suddenly cooled, the stronger and more ductile will it be. In short, violence of cooling, both as

regards the rate of cooling and the range of temperature passed through, strengthen the material and increase its ductility.

But here a caution. Pieces of a very ductile material may themselves be locally brittle, locally incapable of enduring much distortion without rupture; pieces of a strong material may themselves be relatively weak. Notch a piece of cloth, and you may easily rip it across, though, if unnotched and twisted up into a rope, it would hold five tons. Nick a bar of steel, and a light blow will break it; file away the sides of the nick, and round and smooth the surface there, and you will find the remaining metal still strong. Thus, a crack causes the material to yield to trifling stress, by concentrating that stress into a limited region.

Now, we all know how easy it is to crack common steel when we harden it by plunging it into water while red-hot. And we know that these cracks are caused by the difference between the rates at which outside and inside cool.

The outside cools rapidly, and hence tends to contract rapidly; the inside cools much less rapidly; hence it contracts less rapidly, and thus opposes the effort of the outside to contract, and to reach the dimensions which it would naturally have at the existing temperature. The resistance of the inside thus, in effect, violently stretches the outside, and may stretch it so far as to crack it.

We all know that pieces whose shape causes great and sudden differences between the rate of cooling and contraction of different parts, and especially of adjoining parts—that is to say, pieces of suddenly and greatly varying thickness, are especially liable to crack in quenching.

Much the same holds true of manganese steel, though in an incomparatively smaller degree. While the metal is so ductile as to endure without cracking the distortion due to rapid cooling, yet extremely violent cooling, though it may give to the material itself its greatest strength and ductility, may yet, in case of castings whose shape or size favors cracking to an unusual degree, cause slight surface cracks, which, if they be not removed, may in themselves locally lessen the strength and ductility. Hence, the piece which has thus been very violently quenched may be likened to a piece of copper which has been nicked; the material is extremely ductile, but there is a local defect, which locally impairs ductility, and so weakens the piece as a whole, just as a weak link weakens the chain as a whole.

Hence it may be best, especially in treating thick pieces of cast manganese steel of irregular section and greatly varying thickness, to cool at a moderate rate, as, for instance, by exposing to a blast of cold air, or by repeatedly dipping into water and drawing out again into the air. Naturally, this is especially true of unforged castings whose ductility, and hence whose power of resisting the temporary distortion arising during violent cooling, cannot be expected to equal that of forged pieces. Indeed, I have never known even the most violent cooling to injure forged pieces thus.

Forging.—In heating ingots of manganese steel of usual composition prior to forging them, their temperature must be raised very gradually. The metal conducts heat so slowly that, if exposed when cold to a high temperature, the outside becomes extremely hot, and hence expands greatly, while the interior remains almost cold. The fast expanding outside thus stretches the slowly expanding interior, and may stretch it so much as to crack it. Obviously, it is far better never to allow the ingot to cool, but to place it while still hot with the initial heat of casting, in a hot furnace, and simply leave it there till its interior is well solidified.

Once the material has been forged, however, it may be reheated much more suddenly, without danger of cracking.

For forging, the metal is brought to a light-red heat, and at first *saddened*—that is, made compact with light blows; thenceforth it may be struck heavily. But the hardness which it shows when cold persists even at bright redness, and more work—that is to say, more and heavier blows—are needed in forging it than most steel requires. For those familiar with working very hard steel, the whole may be summed up by saying that manganese steel behaves in forging like carbon steel containing about 1.25 per cent. or even 1.50 per cent. of carbon.

Manganese steel may be rolled hot into sheets as thin as No. 18 gauge, 0.049 in., without special difficulty; and it has been rolled hot to No. 28 gauge, 0.014 in., but with difficulty, for very frequent annealing is needed. It has been rolled cold into much thinner sheets, but it hardens quickly in cold rolling, and must be annealed often.

It has been drawn into wire, 0.0105 in. thick, or of No. 31 B. W. G., No. 30 American wire gauge.

Machining.—Manganese steel of usual composition, while unalterably hard, is yet not so intensely hard that we cannot cut it. For cutting it in lathe or planer, the hardest of carbon or chrome tool steel should be used, and the cutting tools should be made as hard as fire and water will make them. Tools made of Mushet's and other self-hardening steel do not cut it readily, as they lose their edge by "slipping." Of course, the cuts must be very light, and the feed very slow. Exact comparative data are not at hand; but such information as I have indicates that it takes about four times as long to machine manganese steel as common carbon steel. This of course does not mean that it costs four times as much.

In general, it is important to bring the metal while hot as closely as possible to the desired shape, so that but little machining may be needed. It may be shaped by drop forging, hydraulic forging and other special means. It may often be cut advantageously when hot by means of a circular saw, as, for instance, in removing sinking heads.

In some cases cold rolling and other forms of cold working may be applied to manganese steel, in lieu of machining. For, while it certainly does not work as easily when cold as common soft steel, yet its disadvantage in this respect seems much less than in cutting by means of common steel tools.

In many cases, too, it may be punched or pressed cold to shape. When only a little of the metal is to be removed, manganese steel may be ground advantageously with an emery wheel. No special precautions are needed, beyond running the wheel rather slowly, as in grinding hardened steel. It

Fig. 10.

costs more to grind manganese steel than to grind carbon steel when unhardened, but decidedly less than to grind hardened carbon steel.

Uses.—Let us next consider the actual and prospective uses of manganese steel.

Its most important single use is for the pins which hold the links of dredgers of the elevator or bucket class, some 4,000 of these pins having been made in the last two months of which I have advices. For these pins a strong and at least moderately tough material is needed, and at the same time one that resists abrasion well, as the sand and grit between the pin and the link in which turns cut sharply. Fig. 10 shows how much better manganese steel resists abrasion under these conditions than the carbon steel with which it competed. The manganese-steel pin, that which is least worn, has endured more than thrice as much as its neighbor.

In other cases of which I have late reports, equally remarkable results have been reached. At Preston, Eng., a full set of manganese-steel pins, after working for eighteen months in sand and gravel, had worn away only about one-eighth as fast as common steel pins. Manganese-steel dredger pins at Hull, Eng., are reported as wearing about one-sixth as fast as those of common steel.

Manganese-steel plowshares are reported as wearing six or seven times as long as chilled cast-iron shares. This is rather surprising, considering that the chilled cast iron is certainly harder than manganese steel.

The side plates of the Blake crusher, those between which

the jaws play, when made of manganese steel, have shown great resistance to abrasion. These particular plates are seven-eighths of an inch thick. When made of hard carbon steel, they were worn out in two months; in crushing granite, when made of manganese steel, they were worn away only one-fourth of an inch in ten and one-half months. In other classes of crushing machinery it has given excellent results.

Other fairly established uses are for the links of chain elevators and for certain parts of safes. For the latter a material which can neither be drilled nor broken seems to offer exceptional advantages.

Of the many prospective uses of manganese steel I will notice but two, for armor plate and for car wheels.

Manganese-steel armor plates 2 in. thick have been tested under the conditions of actual warfare. From these tests it is calculated that, in order to offer the same resistance as a manganese-steel plate, a wrought-iron plate would have to be 77 per cent. thicker, and a carbon steel plate 48 per cent. thicker.

We cannot yet tell whether manganese steel in very thick plates, such as are used for the sides of war ships, would behave as well as it did in these trials; but they certainly seem to commend it for the light plates with which vessels' decks are armored, and for the light shields which protect the gunners.

For railroad car wheels we need a material which, like manganese steel, is so hard that it will not wear away under the friction of the brake-shoe, and yet is so tough that it will not break when it hammers under full load and at full speed against frogs and crossings.

Twenty-two manganese-steel wheels, 30 in. in diameter, on one of the New England railroads, ran from 131,499 to 188,179 miles, or on an average of 168,453 miles before the first turning.

This is nearly seven times the average mileage of chilled cast-iron wheels on this particular road, where the conditions are very trying owing to frequent stops, and the consequent frequent application of the brake. The mileage of these manganese-steel wheels is nearly six times the reported average life (29,074 miles) of cast-iron wheels on the Boston & Albany Railroad. The general belief is that chilled cast-iron passenger wheels, 33 in. in diameter, run on an average 60,000 miles before removal, which is about one-third the mileage of these manganese-steel wheels before their first turning.

The mileage of composite or steel-tired wheels is much greater than that of chilled cast-iron wheels, though the steel tire of the composite wheel is very much softer than the cast iron. That of 720 steel tired wheels on the Boston & Albany Railroad was 111,804 miles before the first turning; the average mileage of these manganese-steel wheels is thus 51 per cent. greater than that of these composite wheels before their first turning.

The first cost of the manganese-steel wheel, which is a simple casting, is much below that of the composite wheel. The cost of the wheelage, or wheel service, consists mainly of the first cost of the wheel and of the interest on this first cost. Calculations which I have made, but with which I will not to-night trouble you, show that the manganese-steel wheel is likely to be much cheaper per 1,000 miles run than the composite wheel.

I believe that the manganese-steel wheel is not only incomparably safer than the chilled cast-iron wheel, but, all things considered, really decidedly safer than the composite wheel.*

Its enormous and extremely constant electric resistance, coupled with its cheapness, as compared with German silver and platinoid, should give manganese steel important applications in electrical engineering.

* A widely circulated statement of the number of steel tires broken on the railroads of the German Empire in the years 1884 to 1889, inclusive, reports many manganese-steel tires as breaking. But the term "manganese steel," as here unjustifiably used, refers to a wholly different material from that described in this paper; indeed, to a true carbon steel merely containing a little more manganese than usual, but I believe never more than two per cent.; certainly nothing like the percentage of manganese which would entitle it to be classed with the manganese steel forming the subject of this paper. Some of this pseudo-manganese steel, lately examined, contained only 0.60 per cent. of manganese.

PONTOONING THROUGH THE ST. LAWRENCE CANALS.

We are indebted to the *Marine Record* for the accompanying illustration, showing the method in use for pontooning vessels through the St. Lawrence system of canals.

The tug *W. G. Wilmot* was built by F. W. Wheeler & Company, West Bay City, Mich., for the New Orleans trade, and as three lightships built to the order of the U. S. Light-house Board had previously been successfully pontooned by the device shown herewith, the builders of the *Wilmot* concluded that no more convenient and thoroughly reliable means to accomplish the purpose in view could be obtained than by ordering the same purchase to be applied to the tug, which, as soon as the order was received, was done, to the satisfaction of all concerned.

TUG WITH PONTOONS ATTACHED.

The draft of water through the canals, while nominally 9 ft., is subject to season fluctuations, and anything over this draft requires pontooning. With a knowledge of this fact, Mr. Lesslie, Manager of the Collins Bay Company, had two cylindrical-formed steel pontoons made, guaranteed to give a large buoyancy of lifting power, and with these pontoons placed alongside, it is only necessary to ballast them with water to a sufficient depth, secure them to and under the vessel, and then pump out the water until the required draft of the vessel has been reached, this having been done in the past several instances, besides leaving considerable spare buoyancy in the cylinders or pontoons, should it be required to raise the vessel any more during transit. The utmost success has so far attended the use of these steel pontoons, and it is expected that they will be largely used during the World's Fair season, as a large fleet is certain of making its way from Montreal to Lake Ontario.

With the development of commerce and ship-building, these and other similar appliances will no doubt be brought into more constant use during the season of navigation, and will form a no inconsiderable feature in the methods of transportation between lakes and seaboard. It is also possible that in the near future adjustable cradles may be used that will close in on the ends of a vessel and occupy no greater space than the beam of the vessel actually calls for; but, until more regular communication is established, it perhaps would not be a paying investment to fit out anything more intricate, elaborate or expensive than the steel pontoons now in use and doing such excellent service.

A NEW LAKE STEAMER, THE "MANITOU."

The Chicago Ship-building Company is at work on a new steel steamer, the *Manitou*, for the Lake Michigan & Lake Erie Transportation Company. It is built somewhat after the lines of the *Virginia*, illustrated in our May issue. Her keel length is 275 ft.; length over all, 295 ft.; beam, 42 ft.; depth to spar deck, 24½ ft.; to hurricane deck, 32½ ft. A water bottom 3½ ft. deep extends the entire length of the vessel, and is divided into eight compartments. In addition to this, seven steel bulkheads will separate the hold into water-tight compartments, which are calculated practically to render the craft unsinkable in case of damage through collision or otherwise. The power of the *Manitou* will consist of a triple-expansion engine with cylinders 23, 38 and 62 in. in diameter and 36 in. stroke, steam for which is to be supplied by two gunboat boilers, each 11 ft. in diameter and 21 ft. long, guaranteed for a working pressure of 160 lbs. An economizer of fuel is to be introduced in the shape of two Sturtevant exhaust fans placed in the base of the smoke-stack. Connected air, bilge and cold-water pumps, independent fuel pumps, and a feed-water heater are features of the machinery. The pistons of the engines will be of cast steel.

Particular attention is to be paid to the interior appointments, furnishings, etc., of the *Manitou*. According to the working designs, passengers will enter the boat on the main deck abaft the engine, where a sliding plate-glass door leads to a reception hall 24 ft. × 26 ft. On one side of this hall is the steward's offices, and on the other the office of the purser. All the facework in this reception hall is polished Mexican mahogany. A baggage-room, parcel-room, barber shop, wash-room, etc., will be found forward and aft of this hall. A broad mahogany stairway leads to the beautiful main saloon, whose 200 ft. of length is broken only by the machinery enclosures, light being obtained from domes over the hurricane-deck houses. The saloon is flanked by a double tier of staterooms, with a gallery for access to the upper tier. The lower staterooms obtain light and air through the medium of deadlights let into the sides of the steamer. The finish of the saloon combines uniqueness with elegance. It is mahogany below and white and gold above, with mahogany gallery railings and staircases—all stateroom doors being fitted with plate glass. Aft of the main saloon is a drawing-room 20 ft. × 22 ft. in size, leading out on the spar deck. The dining saloon is forward on the spar deck, extending the full width of the ship, being 43 ft. in length, lighted by large brass-bound deadlights at the sides and an oval dome overhead, and finished in red birch. The pantry is immediately forward of and adjoining it, and the galley, ice and store-rooms, etc., on the main deck below.

The promenade, which is located on the hurricane deck, is 275 ft. long, and ranges from 6 ft. to 11 ft. in width. It is entirely under cover and fitted with ample sitting requirements. The boats and life rafts are carried on steel bridges overhead. On the hurricane deck are located the ladies' parlor, 16 ft. × 17 ft., and a gentlemen's smoking-room, 15 ft. × 17 ft., which are finished in oak with handsome skylights. The captain's office and sleeping apartment are also on this deck. The portion of the crew belonging to the engineer's department is accommodated on the main deck abreast of the engine-room, and the remainder of the crew on the deck forward and on an orlop deck in the forward hold. The afterhold over the shaft alley is fitted up handsomely with berths for first-class passengers.

There are 120 staterooms for passengers, each fitted with marble washstands and running water, as well as electric lights to each stateroom. A number of the staterooms are of extra large size, finished in hardwood, with brass bedsteads instead of berths; two rooms will be fitted with lounges and Pullman berths, forming parlors during the day. Altogether about 400 passengers can be provided with first-class sleeping accommodations.

The *Manitou* will run between Chicago and Sault Ste. Marie, stopping at Mackinac Island and Harbor Springs, making two round trips each week. Her speed will be about 15 miles per hour.

The cost of the *Manitou* will be about $260,000.—*Evening Wisconsin.*

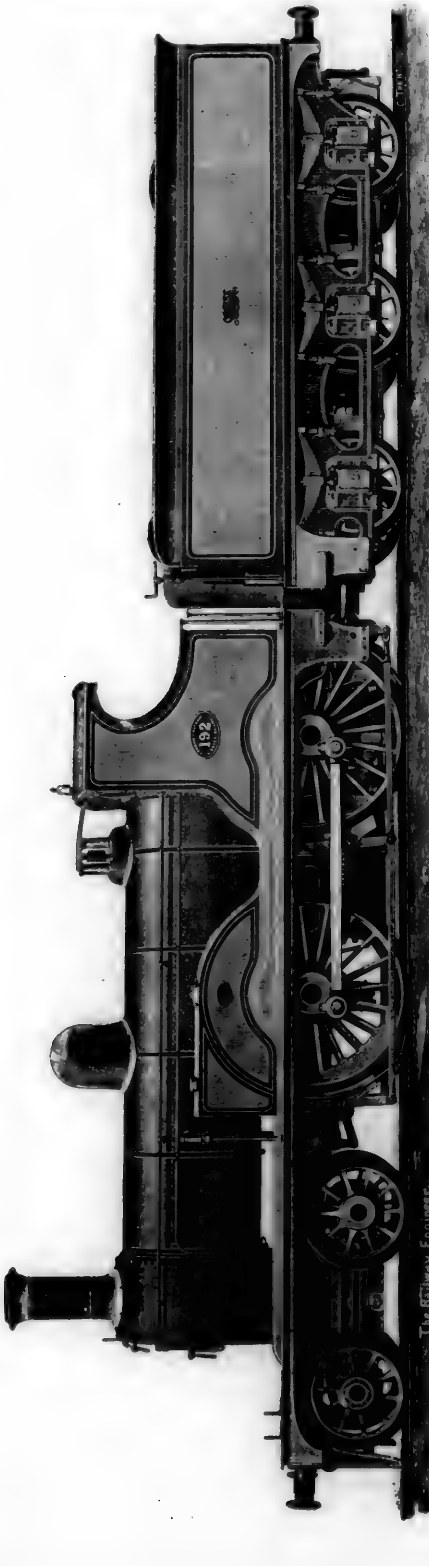
THE NEW REGULATIONS ON GERMAN RAILWAYS.

Some of the new German railway regulations which came into operation a few weeks ago will strike the English tourist as peculiar. That they are useful and even necessary for the proper regulation of the traffic may be conceded, but the oddness of certain provisions is attracting a good deal of attention. Some of the rules are very commonplace, and some are such as have been observed on English railways for years, but in other directions considerable ingenuity has been displayed. It is difficult to understand why time tables relating to passenger traffic intended for stations of the railway which issues them must be printed on light yellow paper, while those posted on foreign lines must be printed on white paper.

It may interest English mothers to know that children under four years of age can travel free on German railways, but like the infants in the London omnibus, they must not occupy a seat. Children from four up to ten years of age pay reduced fares—a thoughtful provision, highly becoming on the part of a paternal government, which is the principal railway proprietor in the country. Should there be a conflict of opinion touching the age of children, the railway official of the highest rank decides the validity of the claim for the time being. The matter afterward forms the subject of official inquiry.

As regards tickets, the system in Germany is much the same as our own. The tickets must indicate the name of the line and also the class and fare. Five minutes before the departure of a train the railways are not bound to deliver any more tickets for that train. The officials may decide that no change will be given at the booking office, and in consequence request passengers to hand in no sum greater than the amount of the fares. Whole compartments, or a part of them, must be secured at least half an hour before the arrival of the train, by paying a sum equal to as many times the fare as there are seats to be engaged. There must, however, be in the coming train a sufficient number of seats or compartments disengaged. This applies especially to sleeping and saloon cars. If a passenger cannot get a seat in any carriage of the class for which he booked, and no seat can be given to him temporarily in a higher class, he can exchange his ticket for one of a lower

TUG RAISED BY PONTOONS.



EXPRESS PASSENGER ENGINE, LONDON, CHATHAM & DOVER RAILWAY.

class, and claim the difference in fare; or he may give up the journey and claim the reimbursement of the fare.

Where a passenger arrives at a junction station at which he has to change trains, in order to travel on another line, he is entitled to the use of the waiting-room, of the latter until his train arrives, and in the night hours between eleven o'clock and six in the morning he is entitled to stop in the waiting-room, provided, of course, it is kept open. Passengers are warned by the ringing of a bell when the time arrives to enter the train. Porters also call out in the waiting rooms the names of the stations at which the train stops. There are some interesting regulations concerning smoking, which is forbidden in all first class compartments unless the whole of the passengers agree to it, but a compartment may be set apart for smokers as well as for non-smokers. A special compartment has to be reserved in each train for ladies, and it is needless to say smoking is absolutely interdicted there as well as in the non-smoking compartments. Smoking is allowed in all compartments of second, third, and fourth-class carriages. Recently, however, a recommendation has been made to set apart a second-class apartment for non-smokers. The regulations extend in some instances to the minutest particulars—for instance, pipes must be provided with lids to obviate the danger of flying sparks.

A traveler who misses his train is not, of course, entitled to compensation, but if the ticket was valid for only one special train he can, after obtaining the *visa* of the station master on his ticket, travel the same day by any train, or the next day by a similar train bound for the station indicated on the ticket. Should the fare by the subsequent train be higher the passenger must pay the difference, but should it be lower, the railway has to refund the difference.

Drunkenness at the stations and in the trains is sternly discountenanced. Drunken people must not be admitted into the waiting-rooms or the trains, but people ejected from the station will be refunded their fare and receive their luggage. If the ejection occurs at a station during the journey, the passenger is refunded a sum equivalent to the fare of the uncompleted portion of the journey; but the luggage which he might have had registered can only be returned at the end station. The same rule applies to people who behave indecently, and those who are afflicted with visible and repulsive infirmities, unless they travel in compartments specially set apart.

The penalties for traveling without a ticket are severe, but to the English traveler they will seem strange indeed. Any one discovered on a train without a ticket in his possession must pay double fare for the distance he or she has traveled. If the name of the station at which the trespasser entered the train cannot be ascertained double the fare for the whole distance the train is running must be paid. This amount must not be less than $1.50. Passengers who, of their own free will, inform the guard or conductor that they were too late to get tickets will only be required to pay the amount of the fare and a tax of 25 cents. The amount must in no case exceed the double fare, but whoever refuses to pay may be at once given in charge of the police. The regulations, I think it will be admitted, have just a slight flavor of the iron rule which obtains in Germany.—*Transport.*

EXPRESS PASSENGER ENGINE, LONDON, CHATHAM & DOVER RAILWAY.

WE illustrate one of the new four coupled bogie express engines which the Vulcan Foundry Company have lately built for the London, Chatham & Dover Railway, to the designs of Mr. William Kirtley, Locomotive Engineer.

These engines work the fast expresses which run in connection with the continental steamers, and some part of the line is very heavy, but the ruling gradient is 1 in 100. The weight of the trains varies from 150 to 220 tons, and the time allowed for the 74 miles between Herne Hill and Dover Pier is 96 minutes, so that the average speed is 46.2 miles per hour.

These engines have worked very satisfactorily, and consume only about 32 lbs. of coal per mile.

The following are the principal dimensions and particulars:

		Ft.	In.
Cylinders, diameter		1	6
" stroke		2	2
Steam ports	$1\frac{1}{4}$ ×	1	3
Exhaust "	$3\frac{1}{4}$ ×	1	3
Lap of valves			1
Max. travel of valves			$3\frac{15}{16}$
Lead full gear			$\frac{1}{8}$
Throw of eccentrics			$3\frac{1}{4}$
Diam. of sheaves		1	$4\frac{1}{4}$
Between centers of cylinders		2	4

		Ft.	In.
Center of exhaust port to center of driving-axle		10	0
Crosshead pin	3" diam. ×		3
Center to center of valve spindle			6
" " expansion links			7
Length of connecting-rod center to center		6	4
" eccentrics " "		4	10
Crank-pins	$7\frac{1}{4}$" diam. ×		4
Piston-rod diam.			3
Frames (steel)—			
Thickness			$1\frac{1}{16}$
Distance between		4	0
Length of frames		27	4
Width over footplates		7	10
Wheels (cast steel)—			
Diam. of driving and trailing-wheels		6	6
" bogie wheels		3	6
Tires, thickness			3
Distance of center of driving-wheel to center of trailing		8	6
Distance of center of driving-wheel to center of bogie		10	0
Center of bogie wheels		5	9
Total wheel base of engine		21	$4\frac{1}{2}$
Coupling-rod crank-pins	4" diam. ×		4
Throw of coupling-rod cranks			11
Section of coupling rod ends	$1\frac{1}{4}$" × 4" middle $1\frac{1}{4}$" ×		$4\frac{1}{2}$

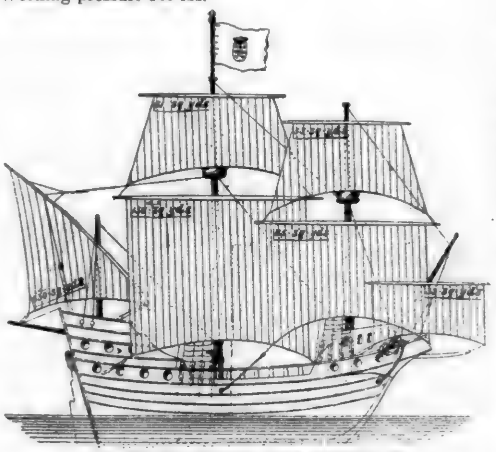
Axles (steel)—

	Bogie.	Driving.	Trailing.
Diam. of center	$5\frac{1}{2}$"	7"	7"
Bearings, diam.	6	$7\frac{1}{2}$	$7\frac{1}{2}$
" length	9	$7\frac{1}{2}$	$7\frac{1}{2}$
Wheel seats, diam.	$7\frac{1}{2}$	9	9
" " length	$6\frac{1}{2}$	7	7
Between center of bearings	3' 7"	4' 0"	4' 0"

Crank-axle webs. Inside 12" × $4\frac{1}{2}$". Outside 12" × $4\frac{1}{4}$"

Boiler (steel)—

Working pressure 150 lbs.



VASCO DA GAMA'S "SAN GABRIEL."

	Ft.	In.
Length of barrel, telescopic two plates	10	5
" " fire-box casing	5	11
Width	3	11
Diam. of barrel, largest	4	3
Depth of fire-box casing below center line	5	2
Thickness of plates in barrel		$\frac{7}{16}$
" " front and back casing		$\frac{1}{2}$
" " covering		$\frac{1}{2}$
" " front tube-plate		$\frac{1}{2}$
Height of center above rail	7	2
Fire-box (copper)—		
Length inside bottom	5	3
Width	3	3
Depth	6	0
Top of box to inside of shell	1	3
Thickness of tube-plate $\frac{15}{16}$" and $\frac{1}{2}$"		
" covering and back plates $\frac{1}{2}$"		
Tubes (copper)—		
205 $1\frac{3}{4}$" diam. outside.		
Length between tube-plates	10	$9\frac{3}{16}$
Diameter of blast nozzle		$4\frac{1}{2}$
Height of chimney from rail	13	$3\frac{1}{2}$

Heating surface—

Tubes	1,010 sq. ft.
Fire-box	110 "
	1,120 "

Grate area .... 17 sq. ft.

Tender—

Wheel base	12	0
Diam. of wheels	3	9

Capacity of coal bunker, $4\frac{1}{2}$ tons.
" water-tank, 2,600 galls.

Weights—
Engine—

	Working order.			Light.		
	Tons	cwts.	qrs.	Tons	cwts.	qrs.
Bogie wheels	13	11	0	12	0	0
Driving "	15	13	3	15	11	0
Trailing "	13	4	1	11	7	0
Total	42	9	0	38	18	0

Tender—

	Working order.			Light.		
	Tons	cwts.	qrs.	Tons	cwts.	qrs.
Front	11	8	2			
Middle	11	10	1			
Hind	11	4	2			
	34	3	1	17	10	0

	Tons	cwts.	qrs.
Maximum weight of engine and tender in working order	76	12	1

—*Railway Engineer.*

VASCO DA GAMA'S SHIP THE "SAN GABRIEL."

The rebuilding of the caravels as reproductions of the vessels composing the fleet of Columbus is soon to be imitated in Portugal, where a facsimile of the ship *San Gabriel*, in which Vasco da Gama discovered the sea passage to the East Indies in 1497, is to be built.

By the assistance of comprehensive data existing in the museums, libraries, archives, cloisters, and churches of the country, an accurate completion of the projected work is not outside the range of possibility, especially since the masterly reproduction by the Spaniards of the *Santa Maria*, which involved researches along a heretofore untrodden path of marine archæology.

The execution of the plan for the new *San Gabriel* was undertaken by Lieutenant-Commander and Hydrographic Engineer Baldaque da Silva and Emeritus Naval Constructor Joaquim José Salgueiro, who, after a lapse of four months, have come out with plans and a model of the ship.

The two investigators availed themselves of the assistance of a description of the *San Gabriel* published by Viscount de Juromenha in 1558, "The Lusiad" of Camoëns, in which the ship is frequently mentioned and a description of it is given; the "Voyages of Vasco da Gama," a book on shipbuilding and designing published in the sixteenth century, and especially the archives of the cloister of Madre de Deus and the city of Lisbon, the book of the Armadas and old Portuguese charts and instruction books.

In the short time since the inception of the work there has been an opportunity for settling upon the main outlines of the ship, though the projectors have not yet determined upon the details, which must necessarily be deferred; yet Señor Baldaque da Silva has published a pamphlet regarding the *San Gabriel* which, next to the Spanish work, "La Nao S. Maria," contains the greatest amount of valuable information regarding shipbuilding in the fifteenth century, and is the source from which the following description of Vasco da Gama's vessel is taken.

General Construction and Hull.—The form of the *San Gabriel*, which is herewith illustrated, is characterized by a long, projecting bow; a high, ornamented stern; a deckhouse fore and aft, and a strong outward swell just at the waterline. The hull bears the unmistakable stamp of marine construction at the close of the fifteenth century, to which we have already had occasion to refer in describing the *Santa Maria*. Inquiries have shown the *San Gabriel* to have been of the following dimensions:

Length over all	88 ft.	11.7 in.
" on water line	63 "	8 "
Extreme breadth of beam	27 "	10 "
Draft forward	5 "	6.8 "
" aft	7 "	8.8 "

From these figures it is calculated that the vessel had a displacement of about 178 metric tons. In old documents, on the other hand, the displacement of the *San Gabriel* is placed at 100 tons, yet this statement should have no weight, for there is no basis for the measurement that would bear investigation. In addition to the foregoing measurements taken from models and pictures, Messrs. Da Silva and Salgueiro have made use of the following data in their calculations :

Height of the metacenter above the center of gravity of displacement	9 ft. 8 in.
Height of the metacenter above water line (loaded)	7 " 4.5 "
Submerged cross section	15.4 sq. yds.
Sail area	444.5 " "
Area enclosed by water line	144.7 " "
Height of center of sail area	65 ft. 8 in.
Center of sail area forward of amidships	4 " 6 5 "

The 178 tons total displacement of the *San Gabriel* would, according to these measurements, be made up as follows :

Battery (20 guns)	6.48 tons.
Ammunition	6.00 "
Masts and sails	8.60 "
Boats and rigging	.70 "
Two anchors and one spare anchor	1 50 "
Hawsers (131 fathoms)	5.00 "
Water supply for 120 days	19.60 "
Provisions for 120 days	21.00 "
Crew (50 men)	3.25 "
Weight of hull	92.00 "
Miscellaneous stores and ballast	14.47 "
Total	178.00 tons.

The vessel had a single deck extending over its whole length, and which, as will be seen from the engraving, had but a single hatchway amidships, while deckhouses were built on the forecastle and quarter-deck. A protective deck was built upon the forecastle for the purpose of sheltering the guns, while the cabin standing on the quarter-deck afforded the only shelter on board for the quarters of the admiral or commandant.

Between decks there was nothing but the deck timbers, the object of which was to serve as braces for any sides or platforms that might necessarily be constructed for the reception of a cargo taken on board.

The main-deck carried the principal battery, which, as is shown by the engravings, was arranged to fire from either bow and on either side of the quarter-deck, while the remainder of the guns were placed in the cabin.

On the lower portion of the main-deck there was a sort of standing place from which the vessel was navigated. On either side of this place there was a small gang-board which also served as the rail, and extended the length of the depression amidships.

It was beneath this gang-board that the watch on deck sought shelter from the weather while the watch below slept in the forecastle.

The space beneath the quarter-deck was reserved for the ship's officers and their equals who might take passage on board. The ship's hold was divided into three compartments, the one amidships being reserved for the storage of water-casks, provisions, and cordage ; the after one for the accommodation of ammunition, while the one forward served for the use of the carpenters and sailmakers. There was also a small space reserved for the storage of wares intended for barter and gifts.

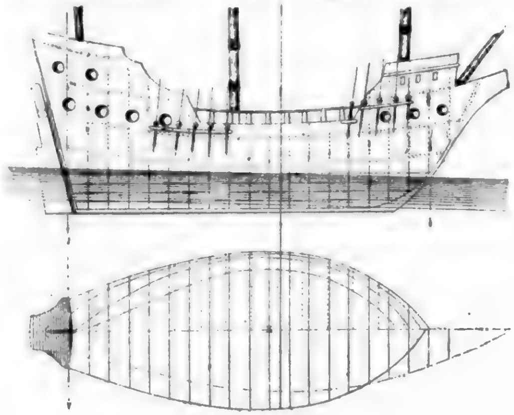
Regarding the construction, it may be mentioned that the vessel was built of carefully selected, sound timber, which was firmly bound together with iron bolts.

The framing extended only up to the scuppers of the main-deck, and extended from there to the top futtocks. It was formed of two courses bolted together. The form of the cant frames and fashion pieces must have been of a very primitive design, so that the vessel would have been very seriously hampered thereby. The sternpost tapered from above downward, and the top timbers of the fashion piece were upright as they corresponded to the form of the poop-deck. The inner planking was very securely fastened, for it was only by this that the deck timbers were held. Likewise the outer planking as well as the mainwale and sheer-rail was most firmly secured. The forward end of the outer planking was let into a gaining in a false stem and aft in the sternpost ; the space between the planking was caulked with wooden strips.

Along each side of the vessel there were three strong fender timbers. The fore and mainmasts had chainwales and irons, such as are used at the present time.

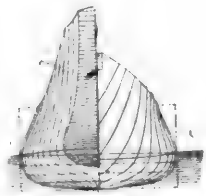
For ornamentation the hull carried a figure-head representing the Archangel Gabriel with arabesque carvings on the prow and stern. The main works were coated with pitch as a protection against water, while the hull was painted outside with ochre and inside with oil paint.

Masts and Sails.—The vessel had three masts and a bowsprit, and for sails a spritsail, two courses, two topsails, and a lateen-shaped spanker. The mainmast was a single stick, well banded, carried on short wedges, and reaching down to the keelson. It was stayed by four shrouds on either side, which were tightened with dead eyes and lanyards. In addition to this it had a double backstay which passed through an eye at the upper end and was tightened below by a lanyard. The foremast was shorter than the main, and differed from that on the square-rigged caravel of Columbus in being stepped further forward. In rigging it only differed from the mainmast in having a single backstay, which was led through a deadblock and fastened to a second deadblock attached to the bowsprit. The spanker mast was shorter and lighter than either of the other two, and went down through the cabin with a step on the quarter-deck. It was stayed by shrouds on either side and also by a stay to the mainmast. The bowsprit was a single stick set at a very steep incline ; it rested on a bolster and was held inside by a foot ; the spritsail yard could be run in and out. Both topsails had a swallow-tail shape, and this served principally to keep down the bellying of the closed portions of these sails. The topsails were held by three sheets and a backstay on each side in addition to a mainstay ;



VASCO DA GAMA'S "SAN GABRIEL."

The low line of the plan is the load water-line.



the prolongation of the fore-topsail stay formed the second preventer stay for the bowsprit. The construction and rigging of the upper spars is not worthy of any particular remark, unless it were to call attention to the spanker-gaff, which is attached to the after side of the mast, and was held by a down-haul, two sheets, and two halyards, the inner one of which ran through a block at the top of the mast, while the outer one was rove through a block fastened at the head of the mainmast.

The arrangement, form and area of the sails are given in the sail plan, as illustrated ; in connection with which it may be remarked that the spanker-sheets were made fast to a rigid spanker boom. All the sails were provided with clew-lines, so that they could be clewed up in brails, while the lateen-sail alone, which formed the spanker, could be reefed. Sail was shortened, then, while all or a portion were clewed up.

Two so-called bonnets, which were a kind of lee-sails, were attached to the courses, and were fastened below the bolt-ropes. The sheets were so arranged as to clear, in case of necessity, the clew-lines of the mainsail and those of the bonnets.

Bowlines were provided for all of the square sails of the main and foremasts. The four lower sails carried the sign of the cross, in order to distinguish the vessel as a Christian ship, according to the usage of the day. Cotton duck with a width of 26½ in. was used as a material for the sails.

Armament and Special Equipment.—As the 20 guns forming the armament of the ship only weighed 6.48 tons, each piece must have been quite small. The battery located on the main deck consisted of 12 muzzle-loading lombardos, which fired either stones or lead-covered iron balls, and were attached to wooden carriages, by which a variation in horizontal fire but no change in the elevation of the piece could be made. Six other pieces belonged to the class of so called falconets.

It does not seem probable that these falconets, which had trunnions and lay in stiff, forked bearings, were located in the cabin, as the Portuguese sketches would indicate, since they were usually placed upon the spar-deck. The vessel had two bow and one reserve anchor on board. They were made with wooden stocks and large rings for fastening the cables. The capstan for winding in the cable stood abaft the mainmast. The rudder had a form which is still found on the coast of Holland and also in some of the coasting vessels of the Mediterranean. As its head lay back of its center of revolution, an oblong-shaped opening had to be made in the poop-deck for the spindle. In bad weather or a fresh wind a tackle was used for steering. The safety of the rudder was insured by rudder-pendants with their chains.

There was only one bilge-pump on board, which was located just forward of the mainmast. The galley was built of tiles and, for the protection of the main-deck, upon which it stood, it had an earthen floor.

The fixed ballast consisted of large stones and cast iron, yet in case of necessity broken stone or sand was taken on board in default of the requisite weight of stores. The ship flew a large white flag from the main-top, and, while under the command of Vasco da Gama on the high seas, a long, red pennant floated from the main topsail, showing that an admiral was on board.

In conclusion, this description is wanting in that our readers will have to imagine many details added to this summary of a celebrated Portuguese ship. We think, moreover, that when the new *San Gabriel* comes to be built it may differ in not a few particulars from the outlines as we have described them.

It is very probable, too, that the truth will make but very little change in the dimensions as given by the Portuguese investigators, since it is more than likely that they are correct. It is also well known that the celebrated *Victoria*, which made the first voyage around the world, had a smaller tonnage than the *San Gabriel*, from which it may be clearly understood that in the fifteenth and sixteenth centuries men did not hesitate to make long voyages upon the high seas in small vessels.

These vessels were really handicapped by the abnormal height of the metacenter, so that, in short, they were not suited for deep-sea voyages, although they stood well on the long waves of the ocean; still their light draft made them more especially suitable for navigation along a protected coast and in rivers; then they presented this advantage that they could be practically dry-docked with the aid of the tide when any repairs were required on the hull.—*Mittheilungen aus dem Gebiete des Seewesens.*

GERMANY'S NEW ARTILLERY.

So destructive in its effect is the new German artillery that it is asserted, once the range were found, a battery would annihilate an entire division in a very short time. *Prima facie*, this seems rather to border on the impossible; but when the results of the experiments which were recently made in the presence of the emperor with the new weapons are considered, the task does not appear to be so impracticable after all. The first shot fired in the course of these experiments was at a target placed 50 paces from a wood. The missile missed the target, but plowed its way for 500 yards through the wood. Shortly afterward a large area of the wood was discovered to be on fire. This was due to the shell being charged with a certain kind of powder, the composition of which is a secret known only to the German Government. The splinters from shells burst by this powder and fired by the new gun cover a circle of 900 ft. This is a great improvement on the limited area of ground that was covered by splinters from shells fired by the artillery weapon of 20 years ago. Then it was considered effective shooting if splinters from a shell were thrown within a circuit of 40 or 50 paces, and seven or eight men wounded; but the new gun has a far greater destructive power than this. Another shell fired at an enormous target, constructed by the emperor's orders, covered it with thousands of holes.

The new German field gun might, perhaps, be better described as an enlarged rifle, for that is what it really is. The ammunition, like rifle cartridges, consists of one piece only. Ignition is produced by a ready fuse, and the four kinds of projectiles at present in use—*i.e.*, shell, explosive shell, shrapnel and grapeshot—give place to a uniform projectile, an explosive shell, possessing the combined characteristics of shell and shrapnel. Thus the possibility of a gunner mistaking in the heat of battle one projectile for another will be averted, while the loading, aiming and firing, besides being quicker, for the new arm is loaded and fired in one-third of the time required in working the old gun, and the effect and precision are almost double, will be surer and unattended with danger. The barrel of the new gun is made of cast steel, with a caliber of eight centimeters, and the total weight of the gun, limber and carriage is slightly less than that of the old artillery weapon. Being lighter, the mobility of the new gun will, of course, be considerably increased. The limber and gun carriage are made of iron and iron plates. The limber box is open behind near the gun when in action. The advantage of this innovation is that the projectiles can be served from the limber and ammunition wagon with greater rapidity. Another important feature is that the carriage is supplied with a brake, which counteracts the recoil, the process of loading and firing being thus simplified.—*London Court Journal.*

PASSENGER CAR EXHIBIT OF THE HARLAN & HOLLINGSWORTH COMPANY AT CHICAGO.

The Harlan & Hollingsworth Company, of Wilmington, Del., have on exhibition at Chicago three cars which may be taken as types. One of these, which is not illustrated, is a special car of the Mann *boudoir* pattern, and has been built for the use of the officers of the Ferra Carril de Bahia al Noroeste, in the Argentine Republic. Its compartments are a dining-room and parlor, at opposite ends of the car, with a stateroom, kitchen, pantry, bath and toilet-rooms occupying its central section. The general tone of color of the interior of this car is yellow, the finish is in oak and the upholstered hangings are of old gold. It is lighted by the Pintsch gas-light system. Its dimensions are: Length of frame, 54 ft.; length over platform, 61 ft.; width of frame, 10 ft.; spread of wheels on truck, 7 ft. 10 in.; diameter of wheels, 3 ft.

The other two cars, illustrations of which are given, represent over half a century of progress in car building. The relative length of the two cars, as given by the engraving, is approximately the same as the actual lengths of the originals. The difference between the two cars is even greater than that appearing in the engravings; the older one being the representative of the early stages of the art, while the new one embodies the latest improvements of refinement and luxury.

The original car is too small to be run in modern trains on its own wheels, and was therefore shipped on a platform car as narrow-gauge cars or street cars are shipped. Its dimensions are as follows: Length of frame, 32 ft.; length over platforms, 37 ft.; width of frame, 8 ft. 6 in.; spread of wheels, 4 ft. 9 in.; diameter of wheels, 2 ft. 9 in. In shape it is simply a box, nearly square on its cross-section, containing about a dozen double seats fixed back-to-back and arranged along one side with one long seat along the other side, on which the passengers sat with their backs against the car wall and their feet toward if not in the aisles. The seats are upholstered in gray hair cloth. Crowded full this car would accommodate about 40 passengers. The windows are narrow, stationary single panes of glass, and ventilation is provided for by a movable panel 6 or 8 in. wide at the end of each of the cross section seats. The side walls and ceiling are simply of beaded siding and are painted a light drab; the floor is of common stock boards, not matched, laid lengthwise the car and painted lead color. The outside of the car is painted yellow and is entirely without ornament.

The car which stands opposite this one, as the result of half a century's effort in evolving a perfect railroad coach, is the club car *Plainfield*, built for service on the New Jersey Central Railroad, and for the use of a number of business men of Plainfield who do business in New York City.

This car is the realization of all that a refined and luxurious taste could desire in a coach. The body of the car is painted a very dark blue with ornamentation in gold. It is carried on two six-wheeled trucks. The steps at each end are of easy ascent, the platforms wide, and all the hand-rails about them are of polished brass.

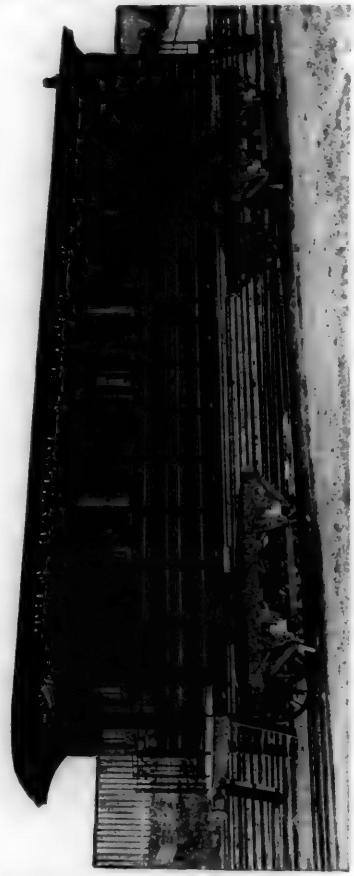
This car is divided into two compartments by a bulkhead across its center, and is finished in mahogany—the walls, bulkhead, doors, tables and chairs being of that wood, and all exquisitely carved and finished. One end contains a heater-room, a linen locker, a saloon and a lavatory. Next to these small apartments is the first main division of the car. It is about 30 ft. long, 8 ft. wide, and under the ventilator about 9 ft. in height. The sides are alternate sections of highly finished mahogany wood, of a dull red color and of the clear-

CLUB CAR BUILT BY THE HARLAN & HOLLINGSWORTH COMPANY.—WORLD'S COLUMBIAN EXPOSITION.

est plate glass; the glass sections, twice the width of the wood, make the car very light and pleasant. The ceiling is of oak, painted in yellow, brown and gold in colonial designs. The wood section of the walls between the plate-glass windows are composed of two turned columns of mahogany, with handsome carved capitals, enclosing a beveled mirror, and behind the mirror—between each pair of windows—is a locker, the mirror being the door of it; the frieze is a handsomely carved belt of mahogany, encircling the car; along the frieze and over each locker is an oxidized package basket.

The furniture consists of 10 tables fixed along one side of the car with four revolving chairs at each table, six or eight big arm chairs along the other side, and several willow chairs about the ends of the car.

There are no upholstered hangings; except the curtains at the windows, the chairs are upholstered in red-brown leather, and the carpet is soft, of the same general tint with sparse



EARLY PASSENGER COACH BUILT BY THE HARLAN & HOLLINGSWORTH CO.—WORLD'S COLUMBIAN EXPOSITION.

dots of deeper color strewn over the surface. The bulkhead of mahogany incloses a circle of plate glass immediately over the door, two circular topped windows, one on each side of the door, and a big rectangular pane of the same quality of glass forming the upper portion of the door. The wood-work about the glass is decorated in beautifully cut figures.

The entrance at the opposite end of the car is through a semi-circular, dome-capped vestibule. The outer walls and the ceiling of this vestibule is paneled mahogany; the walls inside the car and the outside of the dome roof is beautifully carved in floral designs, the figures being in low relief; the door contains panels of plate glass and its hardware is of oxidized silver. The car is lighted by the Pintsch system of gas lights, and each compartment is lighted by three lamps suspended from the ceiling.

The dimensions of this car are as follows: Length, 71 ft. 6 in.; length over platforms, 78 ft. 1 in.; width, 9 ft. 6 in.; spread of wheels, 10 ft., and diameter of wheels, 3 ft.

CONDENSATION OF STEAM IN STEAM-ENGINES.

By B. Donkin, Jr.

There is little doubt that the "forms" of single, compound, or triple engines have a good deal to do with steam condensation, particularly as these forms generally mean considerable cold areas of condensation in contact with the hot steam. The steam temperature range in each cylinder has, according to experimental results, much less influence than the temperature of the metal. When cylinder walls are heated till their temperature equals that of the steam, there is less condensation per square foot of internal surface than with non-heated walls. The indicator diagrams show that the pressure and temperature ranges are increased; so that as compared with cooler surfaces, there is *less* condensation and *greater* range, and experiments confirm this.

Take the case of two modern triple engines by two different makers. Even when made for about the same power, steam pressure, and speed, they differ considerably in their clearances *plus* passages, and also in their volumes, particularly in the extent of the hot or cold internal surfaces. This is probably one reason why similar engines give often very different results in the weight of the steam per indicated horse power per hour.

The extent of the metallic areas touched by the steam and their temperature has not, I think, been sufficiently considered hitherto, and they have a large effect on condensation.

The experiments at Bermondsey prove that non-heated iron surfaces, with non-superheated steam, produce a large condensing effect. Then besides the temperature and extent of surfaces, experiments show the importance of the heat penetration per stroke into the metal walls. This is greater the lower the temperature of the metal, and much less with hotter walls, say with steam jackets or superheated steam. The temperature holes in the metal walls bring this out clearly. With non-heated walls the penetration per stroke may be taken, say, at about ¼ in. and less, depending on speed or time of exposure, etc. We therefore have a certain weight of metal heated and cooled per stroke at the expense of the steam, say, 100° F. range at the surface, and no range at ¼ in. deep. This means the formation of so much water per stroke. So many pounds of iron heated up so many degrees means so many T.U. per stroke lost by the steam and water produced.

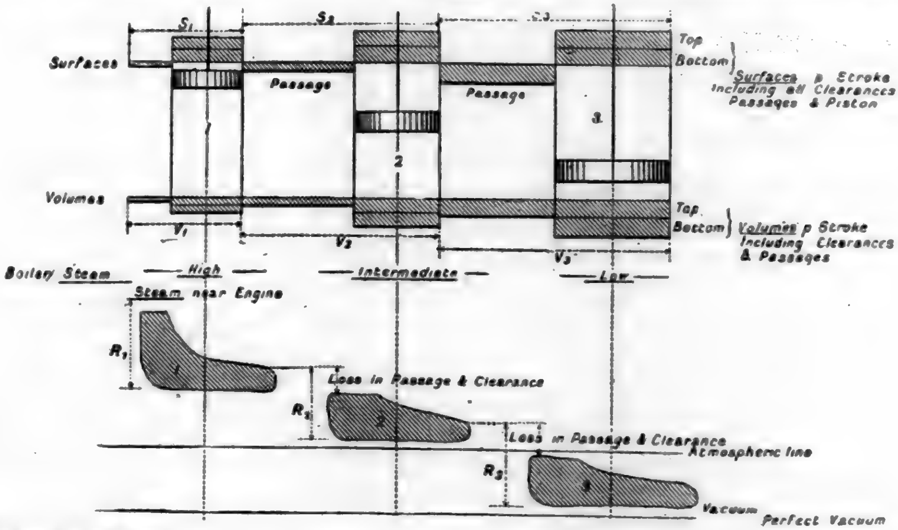
Before a piston moves at each end of each cylinder, condensation on all the boundary walls takes place at constant volume, and the maximum condensation occurs during this time. The steam is at its hottest or maximum pressure, and the metal at its coolest or minimum temperature. This shows the importance of experiments on condensation at constant volume, irrespective of power, with different surface conditions, the internal area and temperature of metal being known.

I add the calculated volumes and surfaces of three different types of engines—single, double, and triple. Perhaps others will help in this direction, and give some actual figures, which are seldom easy to obtain. A sketch of a triple engine is added, showing in a diagrammatic form the range of steam temperature in each cylinder, the depth of heat penetration per stroke into the metal, etc.—*The Engineer.*

Comparison of Volumes and Surfaces Exposed to Steam in Single-cylinder, Compound and Triple Engines (90 to 95 per cent. of stroke taken as release).

	Volume. cu. ft.	All surfaces. sq. ft.		sq. ft.
(1) Small *Single-Cylinder Engine*—(6in. diam.), indicating some 8—10-H.P.	0·130	2·09	or for 1 cub. ft. vol.	16·1 surface.
(2) *Compound Engine* (indicates some 50 to 60-H.P.—				
H.P. cylinder	3·057	16 36	or 1 cub. ft. vol.	5.35 surface.
L.P. cylinder	13·270	38·46	Ditto.	2·90 "
(3) *Triple Engine* (indicates some 300-H.P.)—				
H.P. cylinder	2·454	17·1	or 1 cu. ft. vol.	6·97 surface
I. "	5·128	25·4	"	4·96 "
L.P. "	14·315	47·2	"	3·30 "

These figures include the volumes and surfaces generated by piston, and all clearances and passages between cylinders, also surfaces of pistons.



Steam temp. ranges in the cylinder and passages ..	$R_1°$	———	$R_2°$	———	$R_3°$	degrees.
Depth of heat penetration per stroke into metal in parts of inches	D_1	———	D_2	———	D_3	parts of inches.
Weight of metal heated up and cooled down per stroke, including all clearances and passages ... lbs.	W_1	———	W_2	———	W_3	lbs.

In each cylinder W × mean range of metal Rm × sp. ht. = T. U. per stroke taken from steam and water produced.

Mean temp. Range of metal.	R_1m	———	R_2m	———	R_3m deg.	The mean temp. range of metal is different from steam range.
Feed-water: Wt. steam p. stroke, as per diagram	$Steam_1$	———	$Steam_2$	———	$Steam_3$	lbs. feed-water p. stroke, about same weight of mixture in each cylinder ....
Feed-water: Wt. water per stroke by difference	$Water_1$	———	$Water_2$	———	$Water_3$	

ORDINARY TYPES OF BELGIUM STATE RAILWAY LOCOMOTIVES.

By G. Braet.

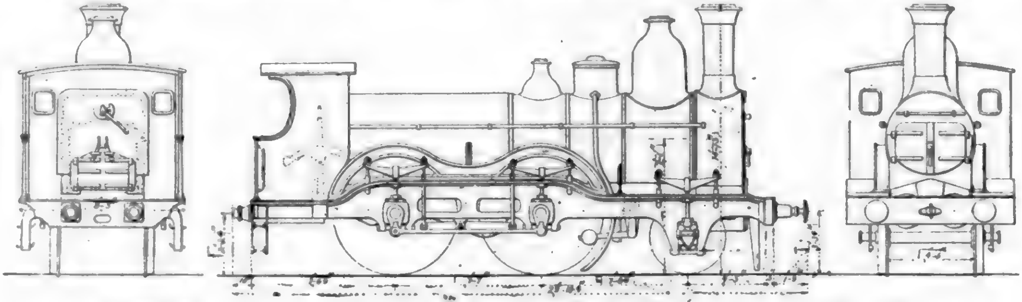
PASSENGER LOCOMOTIVES.

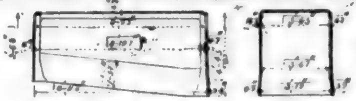
There are several different types of passenger locomotives in use on the State railways of Belgium, which may be said to be distributed through two classes: those with four wheels and those with six wheels coupled. The four-coupled engines embrace the ordinary passenger locomotives (type 1), light locomotives (type 5), and express locomotives. Those with six coupled wheels are: ordinary locomotives with six wheels (type 2), 10-wheeled locomotives with tender (type 4), heavy locomotives for grades (type 6).

The ordinary passenger engine (type 1) has six wheels, of which four are drivers and two belong to a forward truck. The rear driving-axle is beneath the fire-box, and the diameter of the driver-wheels is 2 meters, or 6 ft. 6.7 in.

This arrangement for varying the cut-off is used almost exclusively on all the State railway locomotives. Here, as in all Belgian engines, the valve-rods are guided by bronze bushings pressed into the steam-chest; that portion of the rod which runs in this guide is cylindrical.

The eccentrics are of wrought iron made in two pieces, and are keyed to the axle; the eccentric straps are also of wrought iron, and are held together by bolts with a copper shim in between them, which permits them to be drawn together as they wear. All the eccentrics of the Belgian engines are of the same type. The exhaust is variable at the will of the engine-driver. The axles are of steel, but crank-axles of iron are also used, when the iron is of first-class quality. Spoked wheels of wrought iron with no counterbalance are used. The tires are of Bessemer steel with a thickness of 63 mm. (2.47 in.) when new. Those on the front and back wheels have a width of 140 mm. (5.5 in.), those of the driving-wheels are only 135 mm. (5.3 in.) wide, so that the distance between the inside of the driving-wheels is 1 cm. (.39 in.) greater than between those on the other axles. This arrangement facilitates the motion of the machine on the track, and has received a general application upon all types of locomotives. The truck-axle is fixed rigidly to the frame, and the engine is hung on eight springs above the journals. The springs of the forward and back axles are identically the same. They are made of 13 leaves of steel, each 100 × 10 mm. (3.93 × .39 in.), and their length from center to center of hangers measures 900 mm. (35.43 in.). They have a deflection of 8.4 mm. (3.3 in.) per ton, and are made with a camber of 61 mm. (2.4 in.).





DIMENSIONS.

Diameter of cylinders	16.8"
Stroke of pistons	20.4"
Average diameter of boiler	4' 2.6"
Number of tubes	208
Length of tubes	10' 2"
Diameter of tubes outside	1.77"
Heating surface, firebox	114.5 sq. ft.
" " tubes	860 "

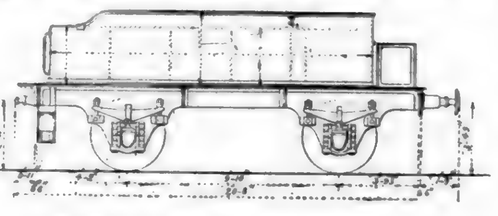
DIMENSIONS.

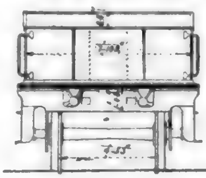
Total heating surface	974.5 sq. ft.
Capacity of the boiler	1,260 galls.
Weight on wheels, forward truck	2,060 lbs.
" " " main driving	29,547 "
" " " trailing	29,215 "
Total weight in working order	60,822 "
Weight of the locomotive, empty	68,465 "

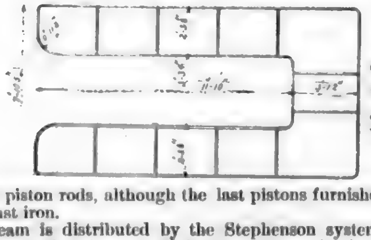
TYPE I., PASSENGER ENGINE, BELGIAN STATE RAILWAYS.

The cylinders are inside and horizontal, and the bronze valves, whose surfaces are very large, are located between them in a vertical position. The cylinders are cast with their back head, steam-chest, and guide brackets solid. The guides are lateral and double with cross-heads cast with a mixture of 2 per cent. tin, an arrangement almost universally found on the Belgium State Railway. The pistons are of the "Ramsbottom type," and are generally made of bronze, attached to steel piston rods, although the last pistons furnished are made of cast iron.

Steam is distributed by the Stephenson system, with the lifting shaft below, the link-operating mechanism consisting of a reverse lever working the lifting shaft. The different points of the steam distribution are marked upon a quadrant, and the lever is fixed rigidly in any position by a screw and nut.







TENDER FOR TYPE I. ENGINE.

Dimensions.

Capacity of tank	1,982 galls.
" " coal chamber	7,088 lbs.
Weight upon forward wheels	24,476 "
" " back "	23,153 "
Total weight in running order	47,629 "
Weight of tender, empty	23,153 "

The springs of the main driving-axles are of two kinds. The outside springs are composed of nine leaves, each 900 × 100 × 10 mm. (35.4 × 3.9 × .39 in.), with a deflection of 13.6 mm. (.53 in.) per ton, and a camber of 59 mm. (2.3 in.); the others which are inside are made of five leaves, 780 × 100 × 10 mm. (30.7 × 3.9 × .39 in.), with a deflection of 13 mm. (.5 in.) per ton and a camber of 51 mm. (2 in.). The springs of the back axles and the outside springs of the main driving-axles are coupled together by means of an equalizing lever.

The upper portions of the journal-boxes are of wrought iron, the lower portions or cellars being cast; they move between two guide-plates of cast iron with which 2 per cent. of tin has been mixed; the wedge is of steel and is made so as to adjust them for their own wear and that of the driving-wheels.

The crank-pins, side-rods and main rods are rectangular and of wrought iron. The main rod has strap ends for the pin and the cross-head, while the side-rods have solid ends.

The front buffer is made of oak.

The fire-box is of the Belpaire type. The advantage accruing from the use of these fire-boxes with semi-bituminous coals is no longer disputed upon the State railways, nor upon other lines which have made any tests with them. The one under consideration is 2.7 meters (8 ft. 10.29 in.) long by 1.08 meters (3 ft. 3.6 in.) wide, and is made entirely of red copper. The outer shell is square and is made of a sheet of No. 4 iron, which is 13 mm. (.5 in.) thick; the sheets are held together by copper stay-bolts 22 and 25 mm. (.86 and .98 in.) in diameter, 10 cm. (3.9 in.) apart; the crown-sheet is stayed by iron stay-bolts screwed and bolted to the outside sheet.

The shell of the boiler is of No. 4 iron, 13 mm. (.5 in.) thick, rolled into a perfectly cylindrical form, and is composed of three sheets. The horizontal seams of each sheet are double riveted, with a welt having two rows of rivets; the vertical seams are formed of a lap 130 mm. (5.1 in.) wide, with a single row of rivets; furthermore, all the vertical joints, as well as horizontal ones, are double riveted, with a welt along the line of the horizontal seams. A sheet of No. 5 iron is used to attach the shell to the outside of the fire-box. Strong stays attach the front end of the outer shell of the fire-box to the cylindrical portion of the boiler, and the side walls of the same are stayed across above the crown-sheet; the tube-sheet of the fire-box is also attached to the shell by means of six stays. The boiler rests upon the frames at three points: one at the cylinders, and by two plates which carry the fire-box on either side.

The tubes are of brass (70 per cent. copper and 30 per cent. zinc), 2.5 mm. (.09 in.) thick and 45 mm. (1.77 in.) outside diameter; they are provided at each end with iron or steel ferrules for making a tight joint with the two sheets. The two sheets forming the smoke-box are of No. 5 iron, while the sheet at the bottom, which protects the cylinders against the corrosive action of the gases, is of copper.

In most locomotives of the Belgium State Railway the smoke-box door is of two flat pieces. The engines are provided with no arrangement for preventing sparks from being thrown out of the stack, a netting and perforated plates having been tried with but little success. The mud-ring is of a single piece of wrought iron, and, where it is practicable, there are manholes for cleaning out the boiler. The management of the Belgium State railways have now done away with the use of these openings, the use of which has not been found to be indispensable.

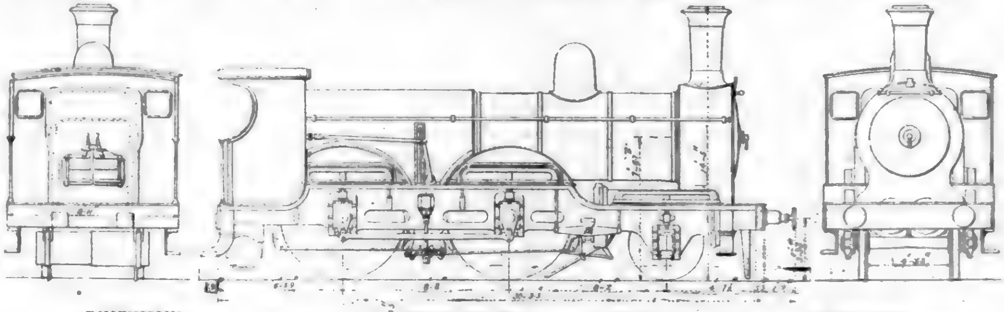
The fire-box door is made in two pieces which open separately. These doors were formerly made of cast iron, but are now made of two sheets of wrought iron 13 mm. (.5 in.) thick, provided with a guide by means of which the fireman can admit air at pleasure to cool off the surface exposed to the action of the flame.

The ash-pan is inclined at an angle of 30°, and has two openings of 32 × 1,000 mm. (1.96 × 39.37 in.) for the removal of ashes and the admission of air, as well as one variable opening of 190 × 1,000 mm. (7.48 × 39.37 in.) at the front end. The grate is partly fixed and partly movable, and has an arrangement of dumping the fire which is located next to the tube-sheet.

A hand-wheel conveniently located for the engineer permits him to shake the moving grate. It is by dumping through this opening that the clinkers and ashes are removed. The boiler has two openings in the shell: one carries the safety-valve seats, the second makes a communication between the boiler and the steam-dome. The dome has the manhole which is taken off when the boiler is to be inspected. The unlocked safety-valve is operated by the spring balance acted upon by means of a lever; it is pressed down directly upon its seat by a plate spring. The steam is taken from the top of the dome; the two valves which control the admission of steam are vertical, and are operated by levers keyed to the same shaft, an arrangement found upon most all of the Belgian State engines. The double valve has given very good results on account of the facility with which it can be handled and the dryness of the steam. The engines are also provided with a whistle which takes steam from the top of the dome.

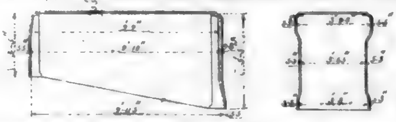
The feed-pumps have been removed from the boiler, two injectors being used in their stead which are of the Schau, Rongy, or Friedman design. These injectors are of the non-lifting type. The feed pipes enter the boiler ahead of the fire-box and about two-thirds of their length down the shell; the check-valve is placed in the pipe just where it enters the boiler. By means of a very simple arrangement it is easy to heat the water of the tender by using the same steam opening which delivers steam to the injectors.

The sand-box is on the shell between the two safety-valves. Two copper pipes carry the sand down and deliver it in front of the main driving-wheels. The boiler has one glass water-gauge, the usual water-cocks and a metallic steam-gauge. Some locomotives of recent construction have two water glasses.



DIMENSIONS.

Diameter of cylinders		17.1"
Stroke of pistons		24"
Diameter of boiler	4'	3.2"
Number of tubes	225	
Length of tubes	4'	11.4"
Outside diameter of tubes		1.77"
Heating surface, firebox	126 sq. ft.	
" " tubes	1,176 "	



DIMENSIONS.

Total heating surface	1,302 sq. ft.
Capacity of boiler	1,612 galls.
Weight of forward wheels	26,769 lbs.
" " main driving wheels	31,730 "
" " trailing wheels	31,642 "
Total weight in running order	90,141 "
Weight of locomotive, empty	81,585 "

EXPRESS LOCOMOTIVE, BELGIAN STATE RAILWAYS.

The locomotives are oiled by automatic lubricators which work when the steam is cut off. The lubricators used are those of Kessler, Henrotte and Furness, and are located on the front cylinder covers.

Several locomotives, especially those hauling passenger trains, have, in addition to the cylinder lubricators, one which works continuously as long as the throttle is open. These are of the Roscoe system or similar to it. They are constructed on the principle of condensation of steam, and their working has been very satisfactory. The connecting and side-rods are also provided with a lubricator of the Berg-March type. The Stauffer lubricators are being tried, and their use promises to become very general.

The axle oil-boxes are lubricated in practically the same way which we have just mentioned. The engine has an air-pump and the brake has four shoes acting against the driving-wheels. Two vertical cylinders are located on either side of the engine between the axles, and they apply the brake to four wheels. The whole boiler is covered with a thin sheet-iron jacket for protection against radiation. The engine has a four-wheeled tender coupled to it by the means of a balanced system of connections which preserve the equality of the pressure on the buffers on curves. The water tank holds 7,500 litres (1,981.5 gals.) of water, and the coal space will hold 3,600 kg. (7,938 lbs.) of fuel. Some tenders, especially those used on express trains, hold 9,000 litres (2,377.8 gals.) of water.

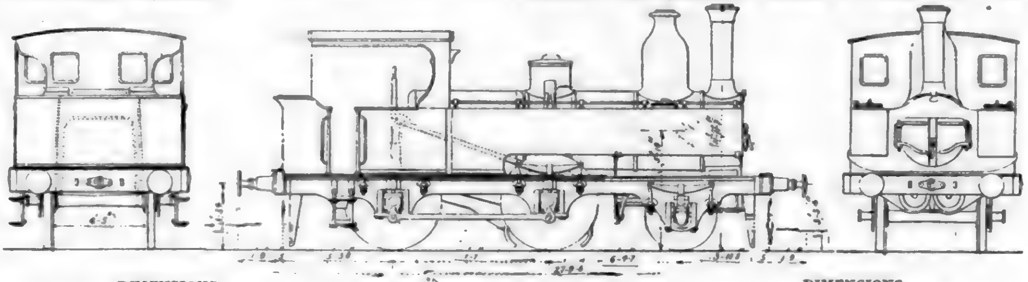
All the essential dimensions of this locomotive, as well as those whose description is to follow, are shown in the table attached. The outlines of the different types of locomotives

and tenders are also shown. Most of the arrangements which are found on this engine are also found on other types of the same administration, therefore the differences alone will be pointed out. The passenger engine with wheels 2 m. (6 ft. 6.7 in.) in diameter is very steady upon the road. It usually hauls, on level track, 15 cars having an average weight of 10 tons each, at a speed of 75 km. (46.6 miles) per hour; but as many of the express trains of the Belgian system of railroads exceed this limit of weight and speed, the management have designed a more powerful type of locomotive which still preserves a resemblance to the lines of the old machine. It is a type built by M. M. Careis, and was shown at the Antwerp Exposition.

bronze, and is provided with check pieces, which protect the connections. The construction of the cross-head for the piston-rod has the peculiarity that, although it is guided by four guides, it permits the forged head of the pin to be put into position without the strap being removed. This is accomplished by lowering the bracket to which the guides are attached, so as to leave the head of the wrist-pin free.

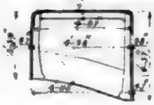
Steam is taken from the dome; the throttle-valve is, however, placed in the smoke-box against the tube sheet, where it is more easily inspected than if it were in the dome.

The ordinary reverse lever is replaced, for the purpose of trial, by a steam reversing-gear composed of two horizontal cylinders, whose pistons are attached to a common rod. One



DIMENSIONS.

Diameter of cylinders		12.6"
Stroke of pistons		18.1"
Average diameter of boiler	3'	6.4"
Number of tubes	145	
Length of tubes	9'	.24"
Outside diameter of tubes		1.77"
Heating surface, firebox	68.2'	
" " tubes	580.9 sq. ft.	



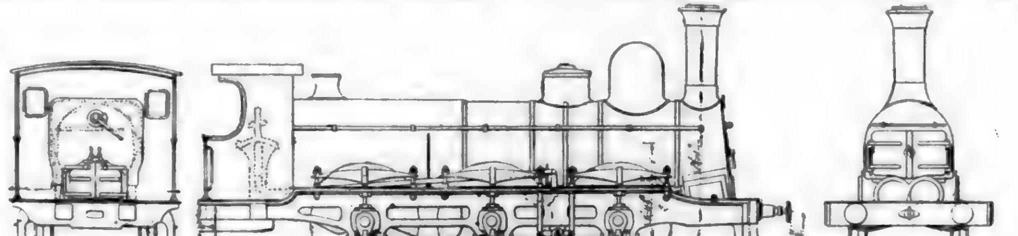
DIMENSIONS.

Capacity of boiler	747 galls.
" " water tanks	945 "
" " coal chambers	2,646 lbs.
Weight of forward wheels	21,168 "
" " main driving-wheels	25,578 "
" " trailing wheels	23,594 "
Total weight in working order	70,340 "
Weight of locomotive, empty	57,330 "

LIGHT PASSENGER ENGINE, BELGIAN STATE RAILWAYS, TYPE V.

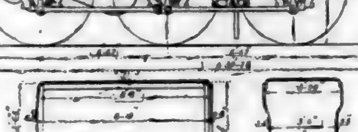
II. *Express Locomotives with Four Wheels Coupled.*—This engine differs little from the preceding one, the fire-box has the same dimensions and construction with the exception of the length, which has been raised from 2.7 m. (8 ft. 10.29 in.) to 3 m. (9 ft. 10.1 in.). The outside frames have been maintained because they permit the fire-box to be widened out to the full distance between the tires of the wheels, thus giving an inside width of the fire-box of 6 cm. (2.36 in.) more than would be possible if the frames were between the wheels.

of these cylinders is filled with a liquid—water, oil, etc. The two ends are united by a passage which permits the piston to displace the liquid by forcing it from one end to the other. In the center of this passage there is a valve, which, when it is closed, cuts off the communication between the two sides of the piston, which is thus held in the position occupied by it at the moment when the valve was closed. The other cylinder is for steam, which is admitted by ports at the ends, causing a forward or backward movement of the piston, thus reversing



DIMENSIONS.

Diameter of cylinders		17.7"
Stroke of pistons		23.6"
Diameter of boiler	4'	3.2"
Number of tubes	226	
Length of tubes	11'	6.2"
Outside diameter of tubes		1.77"
Heating surface, firebox	117.5 sq. ft.	
" " tubes	1059.95 "	



DIMENSIONS.

Total heating surface	1177.4 sq. ft.
Capacity of boiler	14.64 galls.
Weight of wheels, forward	28,224 lbs.
" " main driving-wheels	31,752 "
" " wheels, trailing	27,122 "
Total weight in running order	87,098 "
Weight of locomotive, empty	78,939 "

SIX-COUPLED ENGINE, BELGIAN STATE RAILWAYS, TYPE II.

Together with the outside frame there is an arrangement which has existed for a number of years on the State railroads for freight engines. There is a central frame composed of two strong sheets riveted together which receives a great portion of the reciprocating thrust of the connecting-rods. The cylinders being very near together, but a small portion of their section is carried to the outside frame. The steam distribution is on the Walschaert's system, and presents as one peculiarity the arrangement of the cross-head guide of the valve-stem in which are articulated the forward movement lever and the rod, which transmits to the said lever the movement of the valve. This cross-head is made of aluminum

the engine. By a suitable adjustment the engine-driver can locate the point of the cut-off at will. The engine is provided with a Westinghouse brake which applies eight shoes to the wheels of the coupled axles at the same time.

The cylinders have separate steam-chests provided with two covers; one is very small, which is ordinarily removed for examining the valve; the other is placed laterally, is of larger dimensions, and is removed in case the valve-seats are to be repaired. The valves are of the Allen type with double ports. The extreme wheel base is quite long, and assures the stability of the engine.

The front axle oil-boxes are furnished with guides which

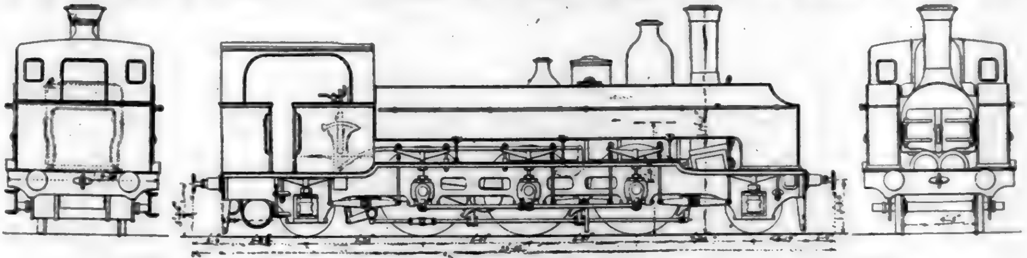
allow a side play when the engine is running curves at a high speed. The contact between the plate and the top of the box is upon an inclined plane, made on two parts so that the tendency is to draw the box back into its normal position, from which it has been taken by the thrust of the rails upon the flanges of the wheels.

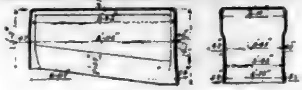
The springs are 1.5 m. (4 ft. 11 in.) long between the hangers. Those at the front and center are formed of 16 leaves of steel 100 × 12 mm. (3.937 × .47 in.), the back springs being composed of 17 leaves. These springs are made without any camber, and are usually convex when loaded. The

13 mm. (.5 in.) thick for the outer case of the fire-box, and of 13.5 mm. (.53 in.) for the shell-sheets, which are subjected to flanging and are of No. 5 iron.

The Wilson's safety-valves are used, and they are placed over the fire-box under the control of the engineer. The sand-boxes are placed beneath the shell against the frames, and the sand is carried down in front of the main driving-wheels.

III. *Light Passenger Engine* (*Type* 5).—This is an engine having a tender and constructed with three frames with four coupled wheels 1.45 m. (4 ft. 9 in.) in diameter, and two-wheeled truck-axle ahead. The cylinders are inside, of small





DIMENSIONS.

Diameter of cylinders	17.7"
Stroke of pistons	23.6"
Diameter of boiler	4' 3"
Number of tubes	226
Length of tubes	11' 6.2"
Outside diameter of tubes	1.77"
Heating surface, firebox	117.5 sq. ft.
" " tubes	1059.7 "
Total heating surface	1,177.2 "
Capacity of boiler	1,474 galls.

DIMENSIONS.

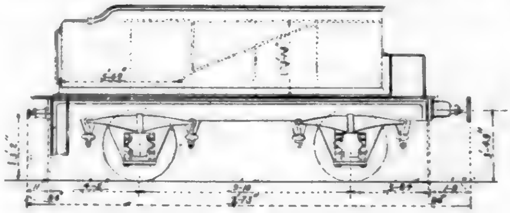
Capacity of water-boxes	2,567.6 gals.
" " coal chambers	8,750 lbs.
Weight of front pair of wheels	22,270 "
" " second pair of wheels	28,665 "
" " third " " "	30,860 "
" " fourth " " "	27,540 "
" " fifth " " "	23,373 "
Total weight in working order	132,708 "
Weight of locomotive, empty	94,815 "

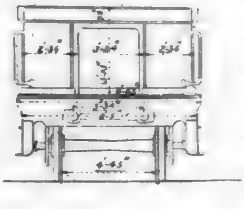
TEN-WHEELED PASSENGER ENGINE, BELGIAN STATE RAILWAYS, TYPE IV.

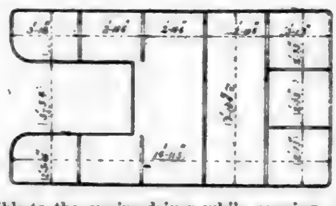
first have a deflection of 16 mm. (.63 in.) per ton; the second, 17 mm. (.66 in.). The spring of the central frame has a length of 780 mm. (2 ft. 6.7 in.). It is composed of 6 leaves of steel 100 × 6 mm. (3.93 × .23 in.) with a camber of 19 mm. (.75 in.); its deflection is 21 mm. (.83 in. per ton).

The equalizing bars are attached to the outside spring of the front axle and the main driver-axle. The outside springs possess the peculiarity that their adjustment is not made with the hangers, but by a column which is called a post, and which is located between the spring band and the oil-box. All the boxes are of phosphor bronze and are solid. All friction pieces have automatic lubricators, which are easily accessible. The injectors are vertical and arranged so as to be accessible to the engine-driver while running. All the boiler attachments are inside the cab and convenient to the men. There is no piping outside the engine.

The oil-box guides are constructed in such a way that the method of attaching the lower parts have check pieces, so that they can be considered as one complete casting, consolidating in the most efficacious way the notch made in the frame for receiving the oil-box. The driving-wheels are 2 m. (6 ft. 6.8 in.) in diameter, and have visible counterbalances. The cylinders are inside and horizontal. The fire-box is of red copper, the tubes of brass. The boiler is made of No. 4 iron







TENDER FOR HEAVY PASSENGER ENGINES, BELGIAN STATE RAILWAYS.

DIMENSIONS.

Capacity of tank	2,378 galls.
" " coal chambers	7,938 lbs.
Weight of forward wheels	27,563 "
" " rear "	23,373 "
Total weight in running order	50,936 "
Weight of tender, empty	23,173 "

dimensions and inclined to the horizontal by 30 mm. to the meter (1.18 in. to the foot).

Walschaert's valve system is used, and, as in all similar constructions, the valve-stem is guided by the packing-box in the steam-chest and by guide supports attached to one of the cross-head guides. The reversing-gear is a hand-lever with a notched quadrant. For experimental purposes phosphor bronze has been used on a few locomotives for valve-seats, guides for the valve-stems, cross-heads, pistons and oil-boxes, phosphor bronze.

The engine is carried by 12 leaf steel springs 900 × 100 × 10 mm. (35.4 × 3.9 × .39 in.). At each end a master leaf is bent into the form of a pad upon which a bolt of the hanger rests. The connection is made by means of these hangers, and iron of the best quality is used in their manufacture, which is well filleted out at every bend. The engines have no equalizing levers nor counterweights in the driving-wheels. The box of the central frame has no springs. The great area and the heating surfaces have been proportioned to the cylinder dimensions; for a width of 1.1 m. (3 ft. 7 in.) in a square fire-box, the length is only 4.463 m. (14 ft. 6.5 in.). The outside shell of the fire-box is 12 mm. (4.7 in.) thick; the shell of the boiler is 11 mm. (4.2 in.) thick; all joints, vertical as well as horizontal, are riveted with a welt; a single line of rivets is used in the vertical rows, while the horizontal seams are double riveted. Two safety-valves are placed upon the dome, one controlled by the balance-lever, the other directly by the plate spring. The sand-box is placed upon the boiler, and as the engine is required to run both directions, two pipes lead the sand down to the front and back of the main driving-wheels.

The engine has a Westinghouse brake applying four shoes to the driving-wheels. A hand-lever with a screw is used to apply the brakes, in case the air-brake fails to work. The injectors are of a small model, but proportioned to the greatest possible consumption of water by the engine. The coal space holds 2,646 lbs. of fuel, and the tank 951.12 gallons of water.

IV. *Engines with Six Wheels Coupled*, of 1.7 *m.* (5 *ft.* 6.9 *in.*) *Diameter* (*Type* 2).—The whole weight is here utilized for adhesion. The frames are composed of three pieces, one being central, and the other two outside the wheels; the cylinders are inside and inclined one-ninth, and have separate steam-chests. The engines built before 1882 have a single steam-chest cover, the more recent ones have two, one of which is very small and is placed in front, so that the valve may be readily inspected; the second is rendered indispensable by the steam-chest being cast in one piece.

The valves are of bronze, many engines being provided with Allen valves with a double port. The valve is held to its seat by means of a plate spring attached to the chest. The steam distribution is accomplished by the Stephenson link. The journal-boxes are of bronze composed of 84 per cent. of copper and 16 per cent. of tin. The wheels are of wrought iron, spoked and without any counterbalance. The tires are of Bessemer steel attached to the wheel center by bolts passing through the center and entering the tire to a depth of about 19 mm. (.75 in.).

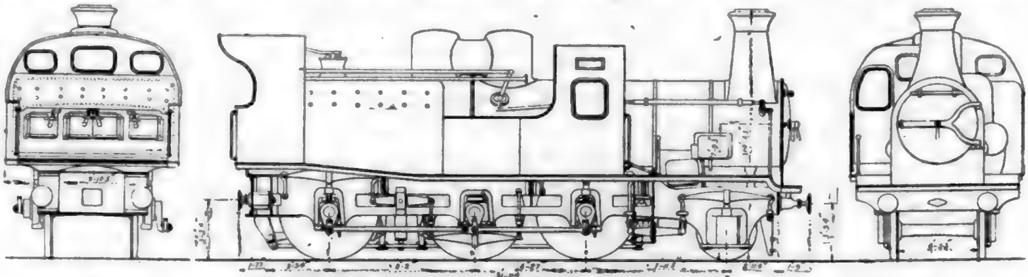
The oil-boxes are made entirely of cast iron and are provided with wedges for taking up the wear. The suspension springs are made of 13 leaves, each 10 × 100 mm. (.39 × 3.9 in.), and measure 900 mm. (2 ft. 11.4 in.) from center to center of hangers, their deflection being 8.4 mm. (.3 in.) per ton. The inside spring of the central frame has four leaves, each 610 × 75 × 10 mm. (24 × 2.9 × .39 in.), and has a deflection of 12 mm. (.87 in.) per ton. These springs are not provided with any equalizing lever. Lately reverse springs of 22 leaves of 10 × 100 mm. (.39 × 3.93 in.) steel have been substituted. They are made without any camber, and are 1½ m. (4 ft. 10.4 in.) long; their deflection is 22 mm. (.86 in.) per ton. The inside spring has been made with some modification; it has a length of 660 mm. (2 ft. 1.9 in.) with a camber of 30 mm. (1.18 in.) and a deflection of 21 mm. (.82 in.) per ton. It is composed of five leaves 100 × 8 mm. (3.93 × .31 in.) in size. The long springs outside of the main driving-wheel and the trailers have been provided with equalizing levers. The fire-box is absolutely similar, both in dimensions and the method of its construction, to those of the passenger locomotives with wheels 2 m. (6 ft. 6.7 in.) in diameter. It is made of red copper throughout. The side sheets, the front tube-sheet and the crown are 12 mm. (.47 in.) thick; engines of recent construction, where the pressure has been increased (type 29), have sheets 14 mm. (.55 in.) thick. The tube-sheet is also of copper, and is 29 mm. (1.14 in.) thick where the tubes are set and 14 mm. (.55 in.) below them.

The cylindrical portion of the boiler and the outer shell of the fire-box are made of No. 4 iron, with the exception of those sheets which have to be flanged, for which No. 5 iron is used. These sheets offer a minimum resistance to a tensile pull of 72,770 lbs. per square inch in the direction of the fiber, and 61,740 lbs. at right angles, with a minimum corresponding elongation of 9 per cent. and 5 per cent. The specification for the copper sheets of the fire-box require that they shall carry before rupture a minimum load of 48,500 lbs. per square inch, and that they have an elongation of at least 22 per cent. of their original length. The assemblage of the sheets offers nothing practically novel, as it is identical with that which we have described in connection with the passenger locomotives with 2 m. (6 ft. 6.7 in.) drivers (type 1). None of the other details or accessories are varied at all. It may be noted, nevertheless, that the Wilson safety-valve has been recently adopted and been placed over the fire-box. As in all passenger locomotives of type 2, these engines also have a Westinghouse brake operating six brake shoes upon the six driving-wheels. This engine is used to haul passenger trains upon grades, and easily takes the load of 80 tons up a continuous grade of 1.6 per cent. at a speed of 34.17 miles per hour.

V. *Ten-Wheeled Passenger Locomotives with Tender* (*Type* 4).—This type only differs from the preceding by an addition of water tanks and coal-boxes. This supplementary load is carried by two axles placed at each end of the engine. The water tanks have a capacity of 10,000 litres (2,642 gals.) of water, and the coal-box can carry 3,000 kg. (6,615 lbs.) of coal. The outside axle-boxes have a radial motion with cylindrical guides; a spring being used to bring the axles back to their normal position when the engine passes from a curve to a tangent. It is by the pressure of the flange of the tire against the rail that the reverse is accomplished. Equalizing levers are used to connect the springs of the truck-axle with the back driver, the front truck springs being also connected by equalizing levers. The effect has been not only to lessen the variation of loads which are inevitably produced with engines of a long wheel base, but to assure a certain safety of running when the axles have a chance for radial adjustments.

VI. *Express Locomotives for Heavy Grades* (*Type* 6).—As we have already said, the locomotives with six wheels coupled with a diameter of 1.7 m. (5 ft. 6.9 in.) can draw upon the long grades of 1.6 per cent from Luxembourg 80 tons at a speed of 34.17 miles per hour. Some express trains, however, which travel over this line frequently have a normal load of 110 tons, and are compelled to maintain a velocity of 40.38 miles upon heavy grades. The management of the State railways therefore ordered a locomotive with six wheels coupled for the service of these fast trains from Cockerill at Seraing. The wheels are 1.7 m. (5 ft. 6.9 in.) in diameter with a radial truck. The principal characteristic of the engine lies in the large dimensions given to the cylinders, the grate area, the heating surfaces and the smoke-box. The cylinders have a diameter of 50 cm. (19.68 in.), a stroke of 60 cm. (23.62 in.), are between the frames and are located between the truck axle and the forward driving-axles. The engine has three frames, the wheels being inside the outer one. The Walschaert valve-motion is used. A steam reversing-gear similar to the one described in connection with the four wheels coupled engine is used. The suspension springs are inverted, their length is 1½ m. (4 ft. 11 in.); equalizing levers are used between the springs of the front and back axles. The grate is 22 m. (6 ft. .17 in.) long by 28 m. (7 ft. 7.8 in.) wide; it therefore extends over the rear drivers. The fire-box is of copper, and is provided with a combustion chamber whose heating surface is .9 of a square meter (9.68 sq. ft.). It is connected with the cylindrical portion of the boiler by two horizontal tubes. The steam space of the fire-box and of the shell are connected through the domes. The fire-box has four doors. The shell has a diameter of 1.4 m. (4 ft. 7.1 in.). The tubes are of iron 2½ mm. (.1 in.) thick. The stack is rectangular.

The engine-driver is not located, as in other engines, at the rear end of the machine, since the special form given to the fire-box renders it impossible to see the signals from this point, and he is placed in a cab on the right-hand side at the junction



DIMENSIONS.

Diameter of cylinders		19.7"
Stroke of pistons		23 6"
Diameter of boiler	4'	7.1"
Number of tubes	240	
Length of tubes	13'	15"
Outside diameter of tubes		2"
Heating surface, firebox	171.5 sq. ft.	
" " tubes	1507 "	

DIMENSIONS.

Total heating surface	1,678.5 sq. ft.
Capacity of boiler	2,246 galls.
Weight first pair driv.-wheels	27,568 lbs.
" second pair driv.-wh'l	30,870 "
" third " "	31,973"
" fourth " "	30,910'
Total weight in running order	121,315'
Weight of locomotive, empty	121,475 lbs.

EXPRESS ENGINE FOR HEAVY GRADES, BELGIAN STATE RAILWAYS, TYPE VI.

of the shell and the fire-box, communication with the fireman being maintained through a speaking-tube. Water-glass and a steam-gauge are at hand by which he keeps track of and can control the fire. This engine has a Westinghouse brake, applying shoes to the six driving-wheels. A tender with a capacity of 14,000 litres (1,321 gals.) is used.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 246.*)

Ascending trends of wind are by no means rare, as abundantly proved by published observations since M. *Pénaud* called attention to the many causes which must produce such trends. This was shown in a very able paper on "Sailing Flight," which was published in part in the *Aéronaute* for March and April, 1875, but which, unfortunately, was left unfinished. M. *Pénaud* demonstrated that such winds must necessarily result from even moderate undulations of the ground (and therefore *a fortiori* from mountains or deep valleys), from natural or artificial objects acting as wind breaks, from the meeting of air currents flowing in different directions, or even from the heating effect of the sun. He doubtless expected to show, in the portion of the paper remaining unpublished, that an upward trend of $\frac{1}{10}$ to $\frac{1}{6}$ (from 6° to 10°) in the wind was quite sufficient to enable a sailing bird to progress against the breeze by inclining his aeroplane so that the horizontal component of the pressure would have a forward direction, while the wind still acted on the under side; for we have already seen in computing the foot pounds expended by a 1 lb. pigeon in gliding, that with a speed of 40 miles per hour and an angle of incidence of 3° the "drift" will be 0.05647 lbs., while the body resistance and that of the edges of the wings together will be 0.05555 lbs., and that at 5° (30 miles per hour) the "drift" will be 0.08892 lbs., and the resistance of the body and edge of wings will be 0.03124 lbs., so that in both these cases the "drift" (calculated even with the coefficients which have been obtained with planes, and which are known to be inferior to those to be expected from concavo-convex surfaces) is sufficient, if directed forward, to overcome the resistances and to give to the sailing bird a forward impulse; this reversal in direction of the "drift," as previously explained, occurring when the plane becomes inclined so as to point forward below the horizon.

Since *Pénaud's* day a great many observations have confirmed the frequent prevalence of both ascending and descending currents. Aeronauts, more particularly, have noted that the atmospheric currents follow the undulations of the ground, causing their balloons to subside upon approaching a valley, or to rise when nearing a cliff or a mountain. They have also inferred, from the fact that they have found butterflies a mile or more above the earth while sailing over table lands, that these trends are frequent in such regions, although their effect upon the balloon is less immediately noticeable than in mountainous countries, where the angle of ascent often is 45° or more. In such broken countries very curious observations have been made as to the invariable prevalence of steeply ascending winds in certain well-defined localities when the wind blows from a particular quarter; such, for instance, as the observations of M. *Mouillard* in the Lybian chain near Cairo, and those of M. *Bretonniere* in the vicinity of Constantine, Algeria, where certain zones or gaps of ascending winds seem to exist, which the sailing birds utilize to gain elevation by circling. There they congregate in crowds, forsaking the rest of the sky, and spirally mount on rigid wings, until they have gained sufficient altitude to carry them toward any point which they may want to reach in descending.

It is probably in sub-tropical regions that such phenomena are most numerous and permanent; but the reader, who is accustomed to thinking of the wind as blowing horizontally, may be quickly edified by watching the smoke issuing from a tall chimney even in northerly climates. This smoke will be seen at various hours, or on various days, to trend either upward or downward or with exact horizontality, as may depend upon the undulations of the great atmospheric waves which are produced by the impinging upon each other of the currents flowing and crossing at various altitudes; or if the observer have the good fortune to be in the regions inhabited by the sailing birds, he may satisfy himself as to the similar atmospheric undulations which are constantly taking place, even in a perfectly flat country, such as the plains of Texas or the sea beaches of Florida, by liberating bits of down or threads of smoke from the same spot at various times or days. He will also observe the local ascending currents permanently produced by a mere wind break, such as a belt of trees facing the inflowing sea breeze. He may satisfy himself (by attaching light strips of bunting or bright-colored threads to the tops of those trees) that the breeze is deflected upward just over their upper branches, and he will then understand why these spots constitute the favorite haunts of the sailing birds when the breeze is light. He will see the soarers for hours gliding back and forth and back and forth on pulseless wings, just above the top of the wind break formed by these belts of trees, evidently utilizing the ascending current to patrol the adjoining beach while awaiting, with no labor, whatever food may be brought by the incoming tide, or an opportunity of eating it undisturbed.

It is not intended here to convey the impression that ascending trends of wind are absolutely necessary for sailing flight. The writer has seen the feat performed many times, when every test seemed to prove that the current was absolutely horizontal; but it then seemed to him that on such occasions the equilibrium was more difficult to maintain, and that the bird had to bestow greater attention upon the nice adjustments required to preserve his balance and to produce "aspiration" when the wind varied in intensity and direction; just as an acrobat experiences greater fatigue in walking a tight rope, through the attention and care expended to avoid falling, than in walking many times the same distance on the ground, where no particular care is required to preserve the balance. It is probably because of such relief from all cerebral strain that the soaring birds seem to sail with less care and with far greater steadiness whenever they are utilizing an ascending current. They are then easily and safely sustained, and so mechanical does the performance seem that some observers have expressed the opinion

Fig. 69.—SIMPLEST CHINESE KITE.

that they then sleep on the wing. There is no doubt, moreover, that ascending trends of wind enable the creatures to soar in lighter breezes than would otherwise be possible, and when the faint morning wind first begins to blow, many of the sailing birds will be seen congregated just above wind breaks, while the other parts of the sky are vacant.

But to return from this digression, occasioned by the feat of "aspiration" performed by M. *Myers'* kites, it will be discerned that the principle of flexibility alluded to confers stability upon the well-known *Japanese kite*, specimens of which are now to be found in almost all toy shops. This kite flies without a tail, the frame being so light and elastic that the surface adjusts itself constantly to the irregularities of the breeze. The side pockets catch the wind, and by springing back of the medial line form a diedral angle which confers lateral balance, while the flexibility up and down confers longitudinal equilibrium. The same principle is exemplified in the upward bending of the extremities of the feathers of birds in flight, which doubtless adds much to their stability, and, indeed, so universally is this principle illustrated by all creatures which navigate fluids, that Dr. *Amans*, in a work upon the locomotive organs of fishes,* lays it down as an axiom derived from physiological consid-

* Comparaison des organes de la locomotion aquatique, P. C. Amans.

erations, that an aeroplane of rigid form is *contre nature*, or in direct antagonism with all the inferences to be drawn from the observation of creation.

The Japanese are expert kite flyers, and have produced many shapes besides that which has been above alluded to. They are said to use kites as weather vanes, and to have hitching posts in their gardens to which the device is almost permanently affixed. Indeed, it is said that these kites sometimes remain 8 or 10 consecutive days up in the air—an astonishing achievement to European and American kite

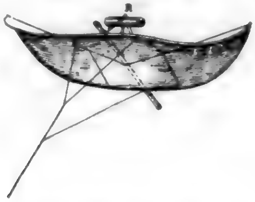


FIG. 70.—CHINESE MUSICAL KITE.

fanciers, who seldom succeed in keeping their apparatus up more than a few hours. The explanation is probably to be found in the greater regularity and permanence of the air currents in the regions of trade winds, and these too are the regions where the soaring birds are most numerously found, probably because they are there sure of a sustaining breeze every day, through the use of which they may evade the fatigue of flapping flight.

The various forms of the *Chinese kites* are even more numerous than those of the Japanese, and most of the tailless kind, are said to depend upon the same principle of flexibility for their equilibrium. It would not at all be surprising to find, should a stable aeroplane be hereafter produced, that it has its prototype in a Chinese kite; but the writer has discovered very little information in print upon the subject; the following article, translated from *La Nature* by the *Scientific American* and published in its issue of March 24th, 1888, being perhaps the best available:

One of our correspondents in China, Mr. Huchet, at present in Paris, has had the kindness to have made for our purposes, by a skillful Chinese manufacturer, a series of models representing the different types of kites used everywhere in China, Annam, and Tonkin, and which the same gentleman has been obliging enough to bring to us in person.

Fig. 69 represents the simplest form of these kites. Its frame is formed solely of a stiff bamboo stick, *A B*, and two slightly curved side rods, *C D* and *E F*. To this frame is pasted a sheet of paper, which is somewhat loose at the extremities *C E* and *D F*, where, under the action of the wind, pockets are formed that keep the affair bellied and in an excellent position of equilibrium. Our engraving shows the mode of attaching

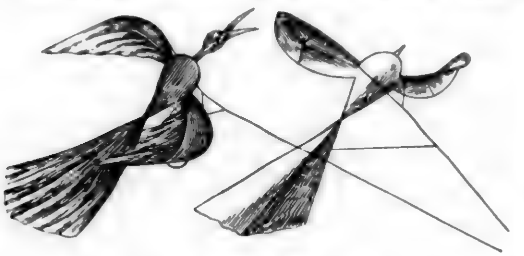


FIG. 71.—CHINESE BIRD KITE.

the strings that serve to hold it. Kites of this kind are usually about three feet in width.

Fig. 70 shows the appearance of the musical kite, so called because it is provided with a bamboo resonator, *R*, containing three apertures, one in the center and one at each extremity. When the kite is flying, the air, in rushing into the resonator, produces a somewhat intense and plaintive sound, which can be heard at a great distance. This kite is somewhat like the preceding, but the transverse rods of its frame are connected at the extremities and give the kite the aspect of two birds' wings affixed to a central axis. This kite sometimes reaches large dimensions—say 10 ft. in width. There are often three or four resonators placed one above another over the kite, and in this case a very pronounced grave sound is produced. Mr. Huchet informs us that the musical kite is very common in China and Tonkin. Hundreds of them are sometimes seen hovering in the air in the vicinity of Hanoi. This kite is the object of certain superstitious beliefs, and is thought to charm evil spirits away. To this effect it is often, during the prevalence of winds, tied to the roofs of houses, where, during the whole night, it emits plaintive murmurs after the manner of Æolian harps.

Among ingenious fancies of the Chinese is their bird kite, fig. 71, the frame of which is made elastic. The thin paper attached to the wings moves under the action of the wind and simulates the flapping of the wings. This kite is sometimes 3 ft. in length.

The most curious style of Chinese kites is the dragon kite, fig. 72. It consists of a series of small elliptic, very light disks formed of a bamboo frame covered with India paper. These disks are connected by two cords which keep them equidistant. A transverse bamboo rod is fixed in the long axis of the ellipse, and extends a little beyond each disk. To each extremity of this is fixed a sprig of grass which forms a balancing plume on each side. The surface of the foremost disk is slightly convex, and a fantastic face is drawn upon it, having two eyes made of small mirrors. The disks gradually decrease in size from head to tail, and are inclined about 45° in the wind. As a whole, they assume an undulatory form, and give the kite the appearance of a crawling serpent. The rear disk is provided with two little streamers that form the tail of the kite. It requires great skill to raise this device.

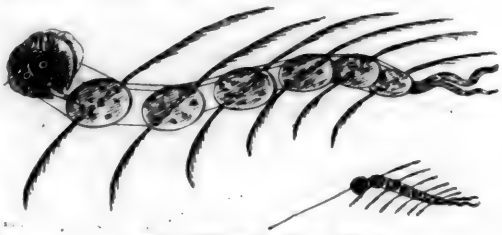


FIG. 72.—CHINESE DRAGON KITE.

This last device resembles in arrangement the multiple disk kites for life saving of the Rev. Mr. *Corder*, already described, and suggests that the superposition of kites affords a good field for experiment. There is a limit in size beyond which the increasing leverage will so add to the required strength and weight of the frame as to make a kite unduly heavy as well as unwieldy,* and superposition naturally suggests itself for experiments intended to test the efficacy and equilibrium of kite aeroplanes. There will be many practical details to work out in devising the best mode of attachment of such aeroplanes with each other, so that all surfaces may pull together and yet counteract the effects of wind gusts, so that experiments with kites seem to offer the readiest, quickest, and least expensive method of working out this part of the problem.

The attention of experimenters is specially called to the form of kite shown in fig. 70. It resembles in shape and attitude those of the soaring birds, which, as already remarked, perform their manœuvres with peculiarly curved and warped surfaces, and it will be seen hereafter that the nearest success in compassing gliding flight hitherto obtained—that of M. *Lilienthal*—has been achieved with just such surfaces.

Inventors seem to have bestowed but little attention upon kites, less than a score of such devices having thus far been patented in the United States. These patents chiefly cover various methods of making the frames to fold, so that the kite may be more portable, while but few inventors seem to have considered how the stability may be increased. Among these latter may be mentioned Mr. *Clarke* (No. 96,550), who proposes the insertion of a spring on one of the three cords which compose the bridle. By the yielding of this spring

* The largest kite on record is said to belong to a Japanese gentleman, and is 50 ft. × 45 ft., weighing 1,700 lbs. Its frame is composed of 350 pieces of wood.

the angle of incidence of the kite may vary somewhat with the varying velocities of the wind, and thus diminish the perturbations.

Mr. *Maddans* (No. 121,056) proposes a kite with a convex surface, this being obtained by providing a stick across the top, which stick is sprung into a bow by attaching its ends to each other; but this bowing seems to have been chiefly devised to attach a flapping tongue, rotating on the bow-string and so making a drumming noise, while there is no doubt that the convexity of the kite must add to its stability.

Mr. *Thompson* (No. 225,306) patents a reversible convex or concave kite, with a frame like that of an umbrella; but nothing is said of the equilibrium or of dispensing with a tail, the object being, apparently, to provide for convenience in carrying.

Mr. *Colby* (No. 354,098) provides for the stability by inserting in the middle surface of a kite a wind bag rearwardly projecting, which is distended by the breeze and prevents the kite from darting. This is virtually the same device as that of Mr. *Copia*, already mentioned, which was found to require a central opening to allow the escape of the air when experimented in large dimensions. It is evident that such a device, if applied to a navigable aeroplane, would largely increase the resistance to forward motion; but this might be minimized by making such wind pockets very shallow, and inserting a large number in the aeroplane. The experiment may be worth trying by kite fanciers.

While several forms of folding frames for kites have been patented by inventors, few seem to have been designed to act as parachutes also. This has been accomplished recently by Mr. *Moy* in a very simple way (British patent No. 1,916, A.D. 1892) by providing the folding frame with a central hub, to which a trapeze bar may be suspended when such a kite is used for conveying passengers or for exploration. By using two lines, the angle of incidence may be controlled, and the kite be made either to raise a weight or to descend slowly to the ground as a parachute.

As already intimated, the writer has found singularly little on record concerning kites, and that little bears but slightly upon the important question of the stability of aeroplanes. It may be for lack of more thorough search that only fragmentary information has been gathered. Kites are supposed to have been invented 400 years before the Christian era by Archytas, a resident of Smyrna (where the flying of kites remains a national sport to this day), and the Asiatics have always been and are now the great kite experts of the world. It is, therefore, not improbable that search in books of travel or inquiries addressed to Orientals might elicit information bearing directly upon the flying machine problem; and it is much to be desired that some competent person shall undertake to write a critical account of kite experiments as well as of the kites of all nations, and of the influence of form as to stability and sustaining power. There is a large collection of Chinese kites in the National Museum at Washington, and it would certainly be interesting to have an account of the various principles exemplified and of the behavior of the various shapes in the air.

(TO BE CONTINUED.)

FOUR-CYLINDER COMPOUND EXPRESS PASSENGER LOCOMOTIVE FOR THE PARIS, LYONS & MEDITERRANEAN RAILWAY.

On p. 499 of our issue for November, 1892, we gave a perspective view of a four-cylinder express passenger compound locomotive built for the Paris, Lyons & Mediterranean Railroad. During 1892 three of these engines were put in service.

These new locomotives, like those built in 1888, are equipped with the Serve tube and steel boilers built for a working pressure of 200 lbs. per square inch; but the use of steel has been pushed still further, and used for the fire-boxes, while in 1888 copper was still used for that purpose.

As in the 1888 type, the cylinders are four in number, the difference being that the high-pressure cylinders, instead of being inside are outside the frames, while the low-pressure cylinders are inside. The two first drive the trailing-wheels and the two latter the forward drivers, the two pair being coupled together, as in the 1888 type; but whereas in 1888 both pair were placed ahead of the fire-box and between two pairs of truck-axles, in the new type they have been pushed back to the rear end of the engine, and the forward end carried by a single pony truck or a four-wheeled bogie.

The valve-motion is of the Walschaert system for the high-pressure cylinders, that of the low-pressure being of a special system without eccentrics, which had already been used for the inside cylinders of the 1888 locomotives.

Reversing is accomplished by means of a steam reversing-gear controlling the valve mechanism of the four cylinders, and fixing, for each point of cut-off, a ratio independently of the engine-driver and properly established in advance.

Finally, the new engines are arranged like those of 1888, so as to permit the direct admission of steam from the boiler into the intermediate receivers between the large and small cylinders. This can be done at starting only and without permitting the exhaust from the small cylinders to escape into the air.

The three new engines are identical with one another, except that two are carried by a bogie ahead, while the third has a single pony truck with a lateral play of ⅞ in. governed by inclined planes of 1 in 10.

The distinctive characteristic of the two engines is their relative lightness. In fact, while the engines of Classes 1 and 2 of 1888 weighed in working order about 53.5 tons, the new engines with bogie trucks, Classes 11 and 12, do not weigh more than 47.9 tons, and those without bogies 45 tons, yet the new engines are considerably more powerful than the old.

But in order to understand the superiority in the power of the new engines, and how they can be made so much lighter, it is necessary to examine into the experiments made in the shops of the Company with the Serve tubes, which formed the starting point for the construction of the new type.

Reference has already been made in these columns (see RAILROAD AND ENGINEERING JOURNAL, pp. 379 and 549, Volume LXV.) to the economy obtained by the use of the Serve tubes. Similar tests made at the Paris, Lyons & Mediterranean shops show an increase of efficiency of 21 per cent.

The reduction in the weight of the engines is not entirely due to the use of the Serve tubes, but is partially the result of the use of steel fire boxes, by which a little more than a ton is saved in the weight of the engine.

Especial attention may well be directed to the conditions governing the designing of the boilers of the new machines, because this is the point in which they differ from those that have preceded it. The second point in which they differ is the location of the axles, relatively to the principal weight of the engine, and especially to the position of the cylinders. The rear axle is still beneath the fire-box, but further back than before. At the front the cylinders are not ahead of the first axle, but the two inside cylinders are exactly in line with the center line of the bogie or over the pony truck; the other two are drawn back toward the center of the machine. The result is a great amelioration of the lateral shocks which the forward pair of wheels or the bogie deliver to the track, when the inequalities of the latter throw the engine to one side, and also a great reduction of the moment which tends to raise the front end of the engines and which is due to the obliquity of the connecting-rods.

The engine rests upon the bogie through the spherical center plate only, so that the load is equally divided between the two rails and the two axles. As each axle is provided with its own springs, it is enough to regulate the suspension links to so arrange it that the four wheels carry an equal load.

The socket of the center plate is not fixed relatively to the bogie. It can turn about its own vertical axis, and as it rests upon a helicoidal surface ascending to the right and left, it rises along these surfaces each time that it turns. Now, this socket turns around its vertical axis at the same time as the pivot, which it draws by means of two fingers provided with rollers, and arranged so as not to hinder the other relative movements of the pivot and the socket. The result is that every angular displacement of the bogie relatively to the engine on the horizontal plan causes a slight elevation of the forward end, so that as soon as the cause of this angular displacement is removed, the weight of the engine draws the truck back into line. This is not, however, the only motion that the socket can make relatively to the bogie. It is susceptible of a side motion on its seat of ⅞ in. on each side of its central position. In order to regulate this displacement, the seat in question rests upon a second lower and immovable seat, with surfaces inclined about 15 per cent. The engines having a single pony truck permit a lateral displacement of the latter on each side of the central position of ⅞ in. with inclined planes of 10 per cent. inclination.

The engines were built upon the compound system, because experience has confirmed the economical results which we would naturally expect when combined with a pressure of 200 lbs. per square inch. Four cylinders have been used, because the experiments made in 1888 have shown that the unavoidable complications resulting from a double mechanism was

Fig. 1

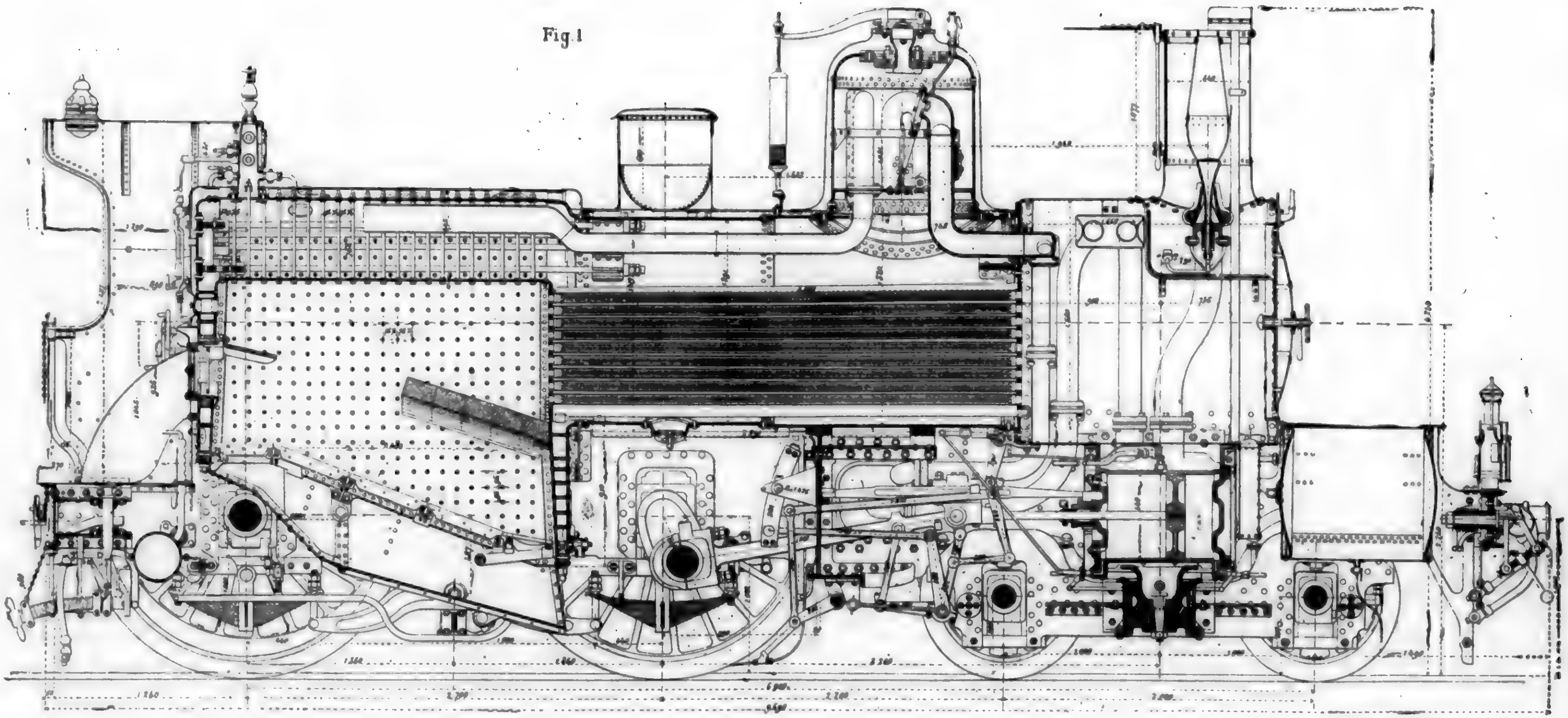
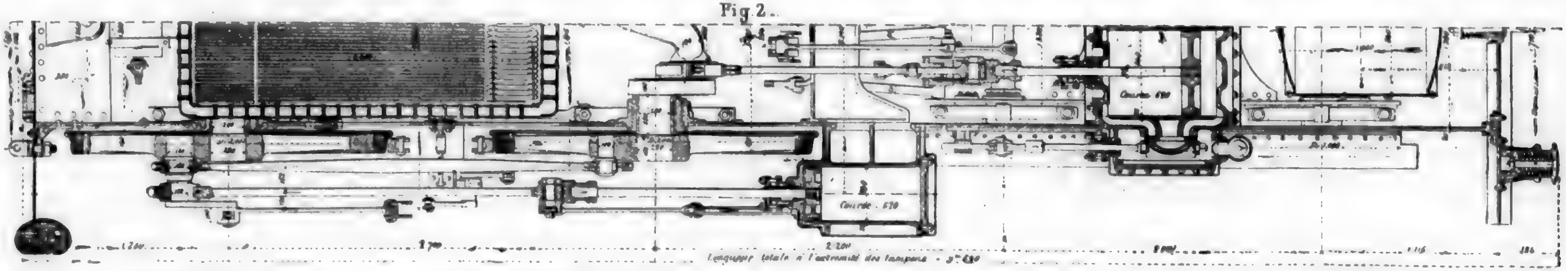
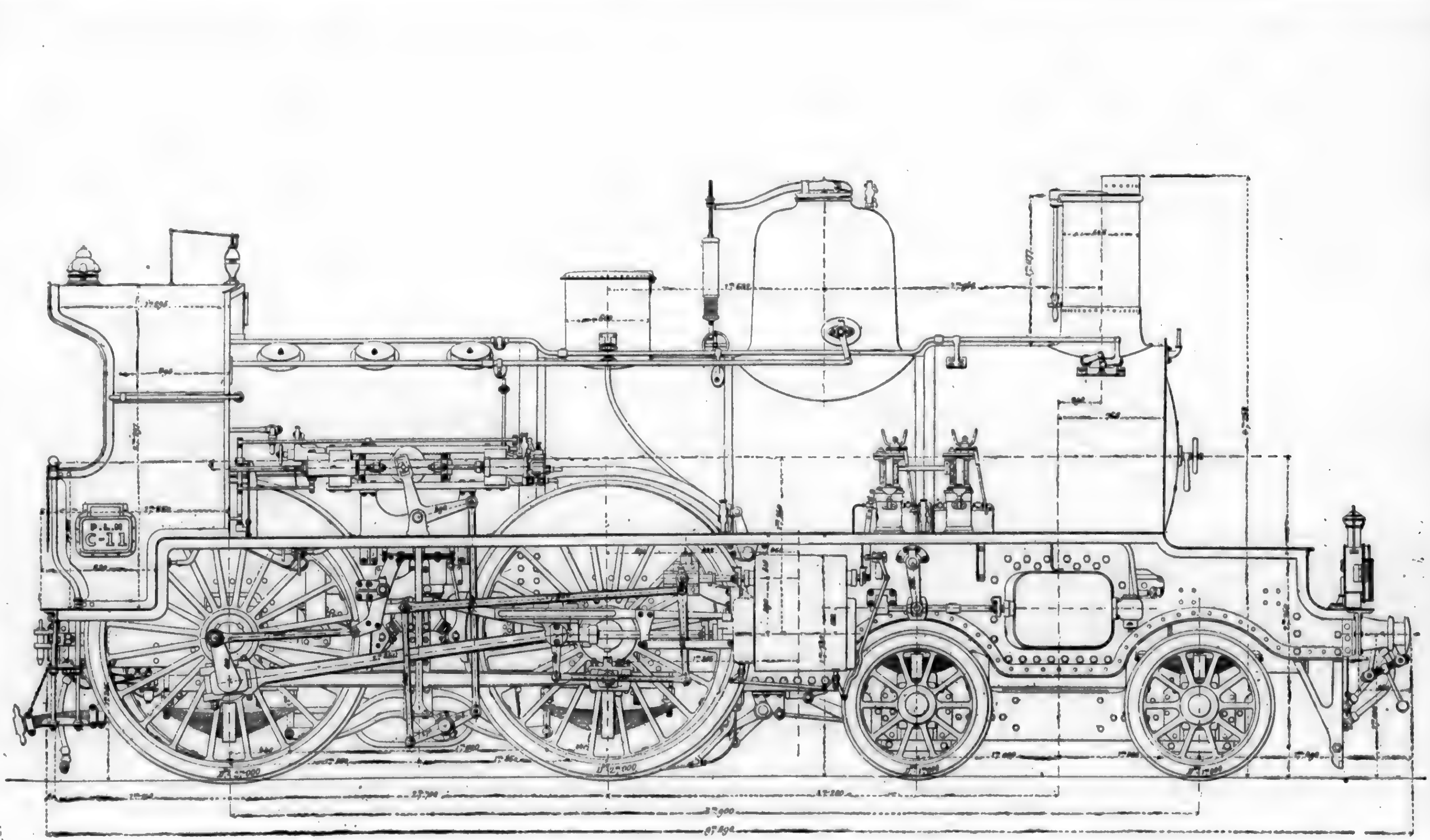


Fig. 2.



LONGITUDINAL, VERTICAL, AND HORIZONTAL SECTIONS OF FOUR-CYLINDER EXPRESS PASSENGER LOCOMOTIVE, PARIS, LYONS & MEDITERRANEAN RAILWAY.



SIDE ELEVATION OF FOUR-CYLINDER EXPRESS PASSENGER LOCOMOTIVE, PARIS, LYONS & MEDITERRANEAN RAILWAY.

perfectly admissible in practice, and because this division of the motive power between two engines, each working on a separate axle, possessed great advantages in reducing the strains on the different portions of the mechanism, upon the axles, and upon the track, and finally, by reducing the disturbances due to inertia. In reference to the overload upon each wheel, the use of four cylinders allows this to be reduced to 3,000 lbs. for the front pair of driving-wheels and 3,250 lbs. for the rear pair of driving-wheels at a speed of 43.5 miles per hour; while, at the same speed with two-cylinder engines, the overload is 9,500 lbs., although the power is 20 per cent. less.

Although each driving-axle is driven direct by two of the cylinders, they have been coupled together in order that the relative angularity of their cranks might remain unchanged, and in addition to this coupling this relative angularity of their cranks has been so arranged that the starting power shall be as great as possible. The cranks of the low-pressure cylinders are therefore 135° in advance of the high-pressure. This is not the best angle when viewed from the standpoint of swaying and heaving; but even in this respect it makes the compound better than the two cylinder engines, even though the latter may be less powerful, as the following table shows:

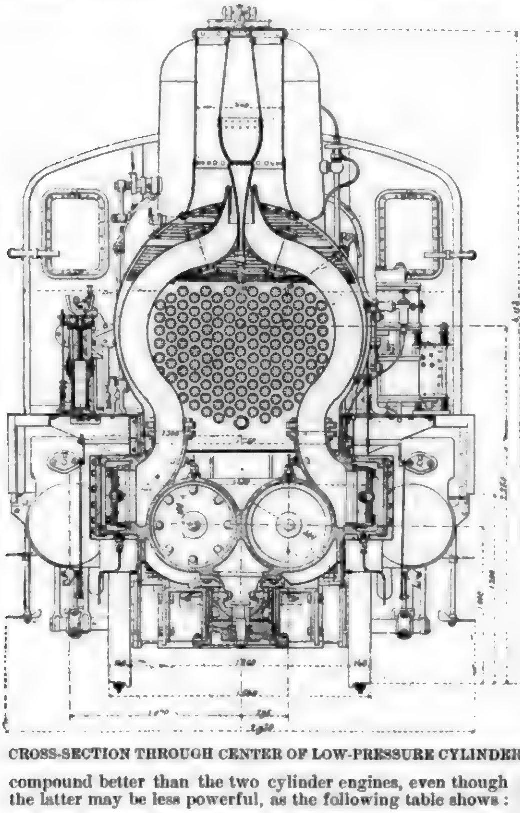
	Simple Engines.	Compound Engines.
SIDE SWAY.		
Maximum of the moment producing the side swaying at a speed of 62 miles per hour	51,160 foot-lbs.	41,201 foot-lbs.
Amount of side sway independently of the speed at the front axle or the center pin of the truck	.055"	.0512"
VERTICAL HEAVING.		
Maximum of the effort producing vertical heaving at a speed of 62 miles per hour	516,650 lbs.	13,570 lbs.
Amount of heaving, independent of the speed	.13"	.13".

The ratio of the volumes of the small to the large cylinders is as 0.40 to 1; and the steam distribution of the two groups of cylinders is so joined as to equalize as much as possible, for every point of cut-off, the diagrams of the small and large cylinders.

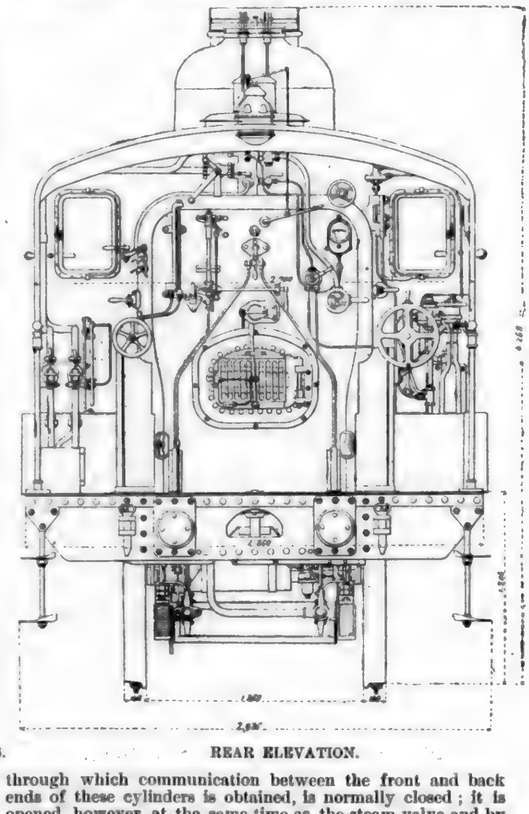
The reversing-gear is so combined as to maintain the desired relationship between the two distributions, by means of two conveniently located cams, whose shaft has a horizontal motion parallel to the center line of the engine, and this motion gives it a simultaneous rotation by means of toothed sectors which are keyed to the cams and mesh in with a fixed rack. The movement of the cam-shaft is accomplished by means of a nut fastened to that shaft and a screw operated by the engine-driver. The operating wheel is furthermore arranged, according to the type adopted by the Paris, Lyons & Mediterranean in 1880, so as to act upon the reversing-screw only after it has opened in the proper direction the single admission valve for steam for the two cylinders, each one of which controls one of the lifting arms. These two cylinders are placed ahead of the cams. Two other cylinders placed behind them are filled with oil and serve to keep the lifting arms immovable while the engine is running; for this reason the single valve, through which communication between the front and back ends of these cylinders is obtained, is normally closed; it is opened, however, at the same time as the steam-valve and by the same motion of the hand-wheel by the driver, the reverse motion closing it. Arrangements are made for filling these cylinders and keeping them perfectly full in spite of leakages.

These new machines have a special steam-valve by means of which the engineman can admit live steam direct into the receiver between the large and small cylinders; there is also a safety-valve on this receiver which opens into the atmosphere and prevents the pressure from rising above 85 lbs. per square inch. The engineman should so handle this valve that he avoids, as far as possible, the opening of the safety-valve. The size of the cock and the pipe which leads from it to the receiver are so proportioned to the size of the safety-valve that the latter is sufficiently large to keep the pressure down to the required limits at all times. With this arrangement, in connection with the coupling of the driving-axles, the starting is accomplished at all times without any difficulty.

The stack is of large diameter, but is contracted on the in-



CROSS-SECTION THROUGH CENTER OF LOW-PRESSURE CYLINDERS.



REAR ELEVATION.

side in accordance with the standard adopted by the Paris, Lyons & Mediterranean in 1888, by a central node placed above the exhaust, and made so as to properly expand the jet of steam.

The exhaust is of rectangular section, and can be varied by means of movable valves.

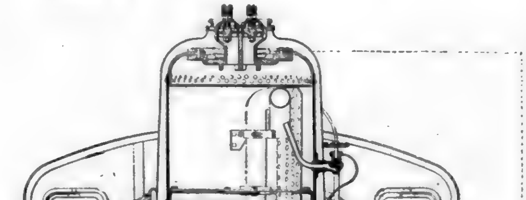
The blower sends steam into the stack through a crown of small holes in this central node.

The boiler is fed by two Sellers injectors of .25 in. and .3 in. nozzles. The cylinders are oiled by a double Mollerup-Dreval lubricator.

The pistons are of cast iron, and the rods are of steel screwed into them. The cranks and pins are of steel. Steel is also used for the axles; the wheel-centers are of iron and the tires of steel. As the crank-axle is not required to carry any eccentric, its two cranks are connected by a straight piece running direct from one to the other. The cranks are banded with a steel hoop, and the pins are traversed through their centers by an iron safety bolt.

The driving-boxes are of the Raymond-Henrard type with three wearing strips, one of which is below and the other two on the sides. Each of the driving-wheels are provided with a brake-shoe which is operated by the Westinghouse automatic apparatus.

The following is a list of the principal dimensions of the engine for which, as well as for the illustrations and the general description, we are indebted to the *Revue Générale des Chemins de Fer*:



CROSS-SECTION THROUGH HIGH-PRESSURE CYLINDERS.

Grate:

Length	7' 3.0"
Width	3' 4.9"
Area	24 sq. ft.
Inclination	20° 40'

Firebox:

Height inside (measuring to the bottom of the mud-ring)	front	5' 11.5"
	back	3' 10.1"
Inside length	top	7' .24"
	bottom	7' 3.9"
Width inside	top	3' 6.5"
	bottom	3' 4.9"
Thickness of steel	side and back sheets	.39"
	tube sheet, at tubes	.78"
	tube sheet, below tubes	.39"

Tubes (Servé):

Metal	Steel.
Number	133
Outside diameter	2.5"
Thickness	.1"
Number of wings in each tube	8
Height of wings	.47"
Average thickness of wings	.10"
Length between tube sheets	9' 10.1"

Heating Surface:

Firebox (from top of mud-ring)	112.16 sq. ft.
Tubes (inside surface)	1478.74 "
Total	1590.90 sq. ft.
Ratio of heating surface of tubes to firebox	13.18 to 1
" " total heating surface to grate area	63.70 " 1

Boiler:

Outside length of firebox		7' 10.4"
" width " "	top	4' 4.7"
	bottom	3' 11.2"
Inside diameter of main course of shell		4' 4"
Length of shell		9' 5.8"
Thickness of shell sheets		.6"
Metal in shell		Steel.
Inside length of smoke-box		5' 4.96"
" diameter of smoke-box		5' 1.3"
Top of rail to center of boiler		7' 4.8"
" " " " bottom of front end of mud-ring		2' 2.8"
Volume of water with 4" over the crown-sheet		761.68 galls.
" " steam space		77.68 cu. ft.
Total capacity of boiler		1342.76 galls.
Steam pressure per sq. in		213 lbs.

Stack:

Inside diameter of stack	1' 9.3"
Diameter of central ring of stack	10.6"
Height from top of smoke-box to top of stack	4' .1"
" " rail " " " "	13' 11.6"

Areas of Air Passages:

Through grate		12.48 sq. ft.
" tubes	at firebox ferrules	2.79 "
	" center	3.70 "
Free inside section of stack		1.80 "
Ratio of stack to tubes		1 to 1.52

Frames:

Inside to inside of frames		4' 1.2"
Thickness		.8"
Outside to outside of foot-plates	front	8' 2.4"
	back	9' 6.1"
Length over buffers		30' 9.5"
Distance between axle centers	first and second	6' 6.7"
	second and third	7' 2.6"
	third and fourth	8' 10.3"
	total wheel base	22' 7.6"

Wheels and Axles:

Diameter of wheels	truck	3' 3.4"
	driving	6' 6.7"
Lateral play of the bogie		.6"
" " " drivers each way		.04"
Distance between inside of tires		4' 5.5"

Cylinders:

	High Pressure.	Low Pressure.
Number of cylinders	2	2
Diameter " "	1' 2.5"	1' 9.8"
Stroke of pistons	2' .4"	2' .4"
Cross section of cylinders	.98 sq. ft.	2.5 sq. ft.
Volume of one cylinder	1.98 cu. ft.	1.48 cu. ft.
Center to center of cylinders	7' .24"	1' 11"
Length of connecting-rods	7' 8.5"	5' 10.8"
Ratio of rods to half stroke	7.58 to 1	5.8 to 1
Inclination of cylinders	0	0

Angular advance of L. P. ahead of H. P. cranks.... 135°

Valve Motion:

		High Pressure.	Low Pressure.
Type		Walschaert	Special.
Kind of valve		Allan.	Allan.
Valve	length	1' 2"	1' 3.7"
	breadth	10.4"	1' .87"
	area	.96 sq. ft.	1.37 sq. ft.
Maximum throw of valve		4.8"	5"
Outside lap		1"	1.4"
Inside "		0	0
Average maximum steam admission per cent.		72.5	75

Steam Passages:

Length of ports	9.4"	1' 1"
Area of steam ports	.08 sq. ft.	.06 sq. ft.
" " exhaust ports	.075 "	.13 "
Steam pipe (area)	.10 "	.17 "
Exhaust pipe (area)	.17 "	.24 "

Volume of receiver.... 9.18 cu. ft.

Weights:

Engine, empty		98,500 lbs.
In working order	truck axles (each)	19,560 "
	front drivers	33,370 "
	back "	33,200 "
Total		105,690 "

LOCOMOTIVE RETURNS FOR THE MONTH OF FEBRUARY, 1893.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Locomotive Mileage. Freight Trains.	Locomotive Mileage. Service and Switching.	Locomotive Mileage. Total.	Locomotive Mileage. Average per Engine.	Av. Train. Passenger Cars.	Av. Train. Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Coal Burned per Mile. Freight Train Mile.	Coal Burned per Mile. Service and Switching Mile.	Coal Burned per Mile. Train Mile, all Service.	Coal Burned per Mile. Passenger Car Mile.	Coal Burned per Mile. Freight Car Mile.	Cost per Locomotive Mile. Repairs.	Cost per Locomotive Mile. Fuel.	Cost per Locomotive Mile. Oil, Tallow and Waste.	Cost per Locomotive Mile. Other Accounts.	Cost per Locomotive Mile. Engineers and Firemen.	Cost per Locomotive Mile. Wiping, etc.	Cost per Locomotive Mile. Total.	Cost per Car Mile. Passenger.	Cost per Car Mile. Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Alabama, Great Southern																									
Alabama & Vicksburg																									
Atchison, Topeka & Santa Fé	834	723				2,061,556	2,851						94.56			5.48	7.76	0.27	0.17	6.78	1.60	22.01			1.56
Canadian Pacific	612		445,782	678,693	303,952	1,428,417	2,333						82.45			4.45	13.74	0.48		5.79	1.58	25.94		2.57	3.29
Chic., Burlington & Quincy	545					1,770,410	3,248	4.75	16.21				99.05			4.89	6.99	0.27	0.36	6.45	0.10	19.06			1.41
Chic., Milwaukee & St. Paul	825					2,678,701	3,244						79.26			4.41	8.11	0.30		6.86		19.68			2.00
Chic., Rock Island & Pacific	552		500,176	871,967	403,656	1,775,799	3,217						72.73			3.06	7.11	0.27	3.06	5.97	0.42	16.83			2.70
Chicago & Northwestern	866		634,864	1,272,480	687,156	2,544,500	2,865						98.96			4.08	9.19	0.39		6.58	0.96	21.15			1.84
Cincinnati Southern																									
Cumberland & Penn*	22	21	4,664	33,044		37,708	1,795						91.07			10.78	4.94	0.41			1.96	18.04			
Delaware, Lackawanna & W. Main L.	210	189				624,104	3,302						91 49			3.19	7.21	0.39		6.62		17.41			
Morris & Essex Division	159		152,983	146,439	97,652	397,074	2,497						69.90			4.13	10.95	0.41		7.22		22.71			3.10
Hannibal & St. Joseph	76					256,875	3,669	5.28	15.18				96.11			4.02	6.18	0.16	0.40	6.32	0.04	17.12			
Kansas City, F. S. & Memphis	146		91,032	282,333	116,509	489,874	3,355						73.85			3.12	6.08	0.28	0.43	7.40		17.26			1.60
Kan. City, Mem. & Birm	42	37	32,735	58,739	12,583	104,057	2,812						72.46			3.99	3.92	0.24	0.36	6.96		15.47			1.04
Kan. City, St. Jo. & Council Bluffs		39	57,370	45,444	38,329	141,143	3,714						71.12	16.23	5.84	3.25	6.68	0.15	0.35	5.85	0 05				1.99
Lake Shore & Mich. Southern	594		399,805	889,199	501,186	1,790,190	3,018			72.62	99.90	39.83	76.95			2.96	6.13	0.12		7.12	0.18	16.51			1.59
Louisville & Nashville		343	397,855	694,512	425,512	1,517,879	4,425	5.15	16.11	69.62	101.48	58.63	91.45	13.61	7.34	3.46	6.05	0.24	1.35	5.00	0.80	18.44	3.26	1.54	1.58
Manhattan Elevated		295	709,290		56,976	766,266	2,597						48.87			2.40	9.90	0.30		8.90		21.50			3.96
Mexican Central																									
Mil., L. S. & Western	112		69,875	118,664	84,851	273,390	2,440						88.49			3.55	12.82	0.24		6.55	1.08	23.69			2.60
Minn., St. Paul & Sault Ste. Marie			58,253	186,907	37,152	247,312		4.14	14.55				98.52			5.29	16.32	0.29		7.03		28.93		2.85	3.31
Missouri Pacific	339	304				1,024,331	3,369	4.32	16.03				96.28			6.33	6.78	0.33	1.40	6.58	1.70	23.07			1.88
Mobile & Ohio																									
N. O. and Northwestern																									
N. Y., Lake Erie & Western		618	415,573	839,548	260,901	1,516,022	2,473	4.40	18.90	96.70	140.70	162.10		22.10	7.40	5.44	9.02	0.39	2.14	7.47	1.21	25.67		2.20	1.53
N. Y., Pennsylvania & Ohio		260	123,588	307,752	138,884	660,174	2,539	5.20	17.00	86.70	149.80	185.90		16.50	8.80	4.07	7.06	0.32	2.43	7.00	1.05	21.93		1.95	1.12
Norfolk & Western, Gen. East. Div.†			106,560	255,934	52,069	414,563	2,607	4.60	20.30	54.90	125.00			11.90	6.20	6.00	3.70	0.70				10.40			
General Western Division†			94,376	266,423	36,046	396,845	2,634	5.32	15.47	76.00	140.00		125.00	14.25	8.77	5.71	4.56	0.66				10.98			
Ohio and Mississippi	116		131,053	159,716	78,654	369,423	3,184						84.74			3.00	3.68	0.23	1.24	5.45	1.43	15.06			0.85
Old Colony		223	312,513	114,794	122,540	549,837	2,419						65.59			3.64	12.33	0.63		6.84	0.81	24.25			3.75
Philadelphia & Reading			430,709	332,623	1,016,859	1,780,191							78.30			4.95	9.67	0.38		6.04	0.87	21.41			
Southern Pacific, Pacific System		720				1,527,423	2,121						68.30			6.09	17.22	0.34	1.50	7.32	1.85	34.32			5.11
Union Pacific	998		658,195	1,173,439	450,616	2,282,250	2,287	5.34	16.03				104.10	17.00	9.01	6.95	9.96	0.44	1.00	8.19	1.18	27.72	4.90	2.16	1.91
Vicksburg, S. & P.																									
Wabash	425	356	361,003	650,273	269,264	1,280,540	3,597	4.87	12.91				96.01	15.78	7.44	3.95	5.32	0.32		6.35	0.90	16.84			1.10
Wisconsin Central	149	112	121,989	189,176	63,726	374,891	3,347						99.10			4.04	11.85	0.30		7.58		23.72			2.36

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

It may be repeated here that the object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help us to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in April, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN APRIL.

Red Oak, I. T., April 3.—Engine No. 2 of the Choctaw Coal & Railway Company, hauling an east-bound way freight train, exploded as it was leaving the boundaries of this town, causing the death of four trainmen. They were: I. P. Durnell, engineer; F. Fredericks, fireman; a brakeman and hostler. One of them, who was riding on the pilot, was found under the engine trucks. The other three, who were in the engine cab, were thrown 80 ft. from the engine.

Edwardsville, Ill., April 4.—C. Alspaugh, an engineer, James Hambly and Hugh Woods, firemen, were killed, and Walter McGarrighan, engineer, was badly injured in a collision on the Jacksonville Southern Railroad near the place named. A number of other railroad and other employés were killed and injured.

Pittsburgh, Pa., April 4.—In a rear-end collision, near Packsaddle, on the Pennsylvania Railroad, Harry Brautlinger, engineer, had his nose broken, head cut, and arms and shoulders badly bruised, and A. W. Marsh, fireman, had his face badly cut and legs bruised. An engine was smashed and eight cars were demolished. A number of other employés were so seriously hurt that they will probably not recover.

Niagara Falls, N. Y., April 4.—The express and passenger train on the Niagara Central Railroad, which left St. Catharines, Ontario, at 3 o'clock to-day for this city, was derailed in a cut this side of Thorold, Ontario, and the engine and five freight and express cars were ditched. None of the passenger cars were derailed, and fortunately no passengers were injured. James McDonald, fireman on the engine, jumped and broke his arm. He was the only man hurt. The accident was caused by the rails spreading.

Rochester, N. Y., April 6.—Fireman Becker, of the West Shore, fell from engine No. 51, striking a switch post. His head is badly cut.

Delhi, Ind., April 7.—A terrible rainstorm weakened the bridge over Wildcat River, near Rossville, and the north-bound Monon vestibule train went through the bridge, killing the fireman, O'Brien, of Lafayette. His body was caught under the locomotive. The engineer, Brooks, escaped with slight injuries.

Baker City, Ore., April 8.—Al Stevens, engineer, and Fred Phelps, fireman, were injured on the Union Pacific Railroad, but we have no other report of the accident.

Harrisburg, April 8.—James Moses, fireman, had been standing on the tank of a Pennsylvania Railroad engine when his head was caught by a wire and he was thrown to the ground. His head was badly cut, and he laid unconscious for over five hours.

Cincinnati, April 8.—An engine on the Louisville, New Albany & Chicago Railroad went through a bridge near Frankfort, Ind., Saturday morning. Engineer was killed and fireman fatally injured.

Rossville, Ind., April 8.—A passenger engine ran into some timbers lying on a bridge. The shock was sufficient to break the trestle and the engine dropped through, turning over as it struck the ground, holding the engineer and fireman in the wreck. The momentum of the train was so great that, though the trucks of the baggage-car and smoker fell down on the engine, the two cars were forced over and remained on the trestle beyond with no wheels under them. The passenger coach passed half-way over the break, its forward truck dropping down and the rear truck stopping on the track at the edge of the hole. This left the coach directly over the break in the bridge. The three sleepers were comparatively uninjured.

Every effort was at once made to rescue the fireman and engineer. The former was first liberated from the wreck, but was so badly hurt that he survived but a few minutes. It was nearly daylight when Engineer Brooks was rescued. He was found to be so badly injured that there are but slight hopes of his recovery. One leg was broken, the other terribly mutilated, and his back is severely hurt. He was held down by pieces of the engine or cab, and was extricated only after several hours' hard work by the passengers and crew of the train.

Green Brook, N. J., April 10.—While the Eastern express was going about 60 miles an hour, the report before us says, "Suddenly there was a terrific jerk and whizzing sound, followed by a succession of shorter jerks and a loud crash. Both driving-rods had snapped at the same time, and were thrashing through the air with the revolutions of the wheels.

"Joseph Lutz, the engineer, applied the brakes, and the engine, suddenly brought to a stop, reared on end, but came down on the rails again. The cars rebounded with the shock, knocking the passengers against one another and throwing to the floor several who had risen.

"Just as the brakes were applied the rod on the engineer's side came up through the iron floor of the cab and tore a hole in the boiler. The escaping steam scalded the engineer badly about the face, but he kept his post until the train came to a standstill."

Whether it was the main connecting or the coupling rods which broke is not clear from the above account. Probably it was the latter.

Rome, Ga., April 11.—In a collision of two freight trains on the East Tennessee, Virginia & Georgia Railroad at Brice's, the engineers and firemen escaped by jumping, but one fireman fell head first and lost one eye and received some bad bruises. The others were severely bruised, but there was nothing fatal.

Macon, Ga., April 11.—A freight train was wrecked on the Southwestern Railroad, near Butler. Engineer R. F. Reeves, of Macon, jumped from the engine and was severely hurt on the right shoulder, a gash cut on his head, and injured internally.

Norwalk, O., April 11.—As a passenger train reached the Newton Street crossing, Frank P. Mitchell, an engineer on the Wheeling & Lake Erie Railroad, attempted to jump from the rear car. In jumping his heel struck a heavy plank, tearing the heel from his shoe and throwing him head first against the carsteps. A big hole was knocked in the back of his head, exposing the brain. Chances are against his recovery.

Canton, O., April 15.—While I. R. Whitman, an engineer on the Cleveland, Lorain & Wheeling Railroad, was running his train in on the weigh switch at Chamberlain, one of the rails under the engine turned, throwing the engine down the embankment a distance of 30 ft., and dragging three cars with it. Whitman saw the engine start and leaped out of the cab through the fireman's window. He fell on the rails and struck on the spinal column. Paralysis of the lower portion of his body ensued, and he died about 10 o'clock Sunday morning.

Fireman Walker, of Lorain, was also in the cab, and not discovering the accident until too late to leap, clung firmly to the engine and came out without a scratch. The engine in going down the embankment made one complete revolution and half of another, and is a complete wreck. How the man in the cab escaped is a mystery to those who saw the accident.

Waco, Tex., April 17.—An incoming cattle train on the San Antonio and Aransas Pass Railroad ran into an empty train standing on the main track at this station this morning. The cattle train engine, which was just out of the shops, was completely wrecked. Fireman Smith was caught in the ruins and scalded to death. Engineer Browning was scalded, had his left arm broken, and received internal injuries.

Toledo, O., April 17.—A new mogul engine which was put on the Toledo, Ann Arbor & North Michigan Railroad four months before was in charge of Engineer Cavanaugh and Fireman Thomas C. Wilson, the latter a new man from Pontiac, Mich. Cavanaugh telegraphs that about a mile north of Emory, while going slow, the crown sheet let down, and the escaping steam scalded Fireman Wilson so badly that he died soon after.

Rochester, N. Y., April 17.—A fast mail train on the Auburn Road collided with a line of freight cars this afternoon. Engineer John McMannis jumped from the cab just before the crash came. His head struck a projection of the mail car, and his blood and brains were scattered over the entire side of the postal coach. Clarence Aldrich, the fireman, remained in the cab, crouching close behind the boiler

and escaped with no serious injuries. Several other railroad employés were injured.

Port Jervis, April 19.—Engineer O. H. Davis, who runs the fast train over the New York, Oswego & Western Railroad, met with what might have been a serious accident on Wednesday. He was looking back from the window of his cab when his head came in contact with the mail bag hanging on the crane at Parksville. The blow rendered him unconscious for a time, but he rallied, and proceeded with his train to Hancock. An examination of his injuries showed that he was badly bruised.

Whatcom, Wash., April 22.—Charles Welcome, a fireman on the Bellingham Bay & British Columbia Road, had three ribs broken by falling from the engine this morning. He was reaching over the water tank to get a tool from the tool-box, and was struck by one of the poles which hold the feed wire of the electric road.

Albuquerque, N. M., April 24.—In jumping from a derailed engine on the Atlanta & Pacific Railroad, Harry D. McCarty was injured—hip probably broken.

Somerset, Pa., April 26.—In coming down a grade of 150 ft. per mile on the Bare Rocks Railroad, at Ways Station, a train became unmanageable and dashed down the grade with frightful velocity. At the foot of the incline were several loaded freight cars, into which the passenger train plunged. On the engine were Engineer Neff, his son, and John E. Pyle, with his wife and daughter.

The three latter were hurled under the engine as it leaped from the truck and were instantly killed. Neff and his son were fatally scalded. On the cars were a large number of workingmen, some of whom jumped from the runaway train and escaped with slight injuries.

The balance were crushed in the wreck. How many is not yet known. Seven bodies have already been recovered.

Jacksonville, Ill., April 26.—While his engine was standing on the track near the junction, where there is a slight grade, Hardin Garner, engineer, was in the act of blocking the wheels of the locomotive to keep it from moving, and his hand was caught between one of the large drivers and the rail, and two of the fingers on his left hand were cut off at the knuckles and part of the third finger badly mashed.

Albuquerque, N. M., April 26.—The crown-sheet of a passenger engine gave way at Cerrillos, followed by an explosion strong enough to lift the engine from the track, and throwing the big machine on her right side. The explosion tore up the track for some lengths, and the trucks under the mail and express cars flew the track, both cars being twisted to the left of the engine. The engineer, Ed Keene, and fireman, Isaac Taylor, were both badly injured, especially Keene, who is hurt about the face, head, and legs. Taylor is pretty badly bruised about the body, but not dangerously.

Lansing, April 26.—When a mile west of Lansing a passenger train halted on the Chicago & Grand Trunk Railroad, and the signal of distress was given from the cab by means of the whistle. The conductor went forward to the engine, and found the engineer in a very sorry predicament. Coal gas had accumulated in the fire box, which had exploded, setting fire to Ryan's clothing. When aided by the conductor to a passenger-car the clothing that had not been burned off was removed, and as the gloves were pulled off the skin came with them. The fireman escaped injury by climbing through the cab window.

Aurora, Ill., April 27.—In a collision between a passenger train and switching engine on the Chicago, Burlington & Quincy Railroad, Engineer Damon was wedged in among the *débris* of the wrecked switch engine, and it was with considerable difficulty and hard work that he was extricated. It was found that his left leg was broken, his right foot badly smashed, and that he was otherwise bruised about the body.

Celeste, Tex., April 27.—A passenger train on the Gulf, Colorado & Santa Fé Road was ditched by running into a number of horses on the road. The engine and tender were completely demolished, the tender crushing in part of the baggage-car. Engineer Hardeman was almost killed, scalded all over with steam and hot water, and from his suffering must have been almost cooked. He was covered with mud almost beyond recognition when found. His wounds will probably prove fatal.

Fireman Bob Deering was scalded fearfully and burned, but no bones broken.

A number of other railroad employés were injured.

Ansonia, Conn., April 27.—G. W. Lamb, a fireman on the Naugatuck Division of the Consolidated Road, was painfully injured. While at Beacon Falls, he stepped out on a platform at the side of the boiler. He was engaged in cleaning the boiler when his right leg slipped through an opening. He lost his balance and slipped over the side of the engine. Both bones in his right leg were snapped at the ankle.

Ann Arbor, Mich., April 28.—In a collision which occurred in a snowstorm near Emory, on the Toledo, Ann Arbor & North Michigan Road, the fireman was caught in the gang-way on the right side between the cab and tank. We had to saw away the cab, and it was 40 minutes before we got him out. He was still alive and rational, and lived about 25 minutes. This was the first trip of the fireman. The engineer, J. Anderson, was also injured.

Pittsburgh, April 29.—A passenger train on the Baltimore & Ohio Railroad collided with a freight train at Griffin Station, near West Newton. Fireman Thomas Nevill, of the freight, received painful injuries.

The freight train was crossing from the east to the west-bound tracks to get out of the way of the "flyer." The collision occurred at the cross-over switch.

A conductor and passenger were also injured.

Los Angeles, Cal., April 30.—Engineer Harry McCarty was caught in the Atlantic & Pacific freight wreck near Grants, had both legs broken, one of them in two places. He also sustained internal injuries. The wreck was caused by sand drifting upon the track.

Kansas City, Kan., April.—In a derailment in that city —of the date of which we are not advised—which was due to a "split switch," the engineer and fireman were killed. Of the accident it is said :

"At the first jar Engineer Popperts reversed his engine and whistled brakes. Then only did he attempt to escape. While the brave fellow was half-way out of the cab window the engine rolled over and crushed him almost to a pulp underneath. Every bone in his body was broken. Then, to make death's work sure, the burning hot boiler rested on his face, holding him, while the steam scalded his body, which, mercifully, was lifeless ere that.

"Fireman Gatchell, when he saw the danger, jumped from the left side of the cab, but he was caught under a box-car. Four of his ribs and his nose and upper jaw were crushed by an iron brake-rod. He was also terribly ruptured internally. After the crash he crawled out of the wreck and sat down on the ties of a sidetrack a few feet away."

Our report for April includes 32 accidents. In these seven engineers and nine firemen were killed, and 16 engineers and 13 firemen were injured. The causes of the accidents may be classed as follows :

Boiler explosions	3
Broken coupling-rod	1
Derailments	4
Collisions	8
Falling or jumping from engine	3
Went through bridge	3
Wreck	2
Jumping from car	1
Run-away train	1
Struck by objects	3
Gas explosion	1
Hand crushed	1
No cause given	1
	32

THE CONSOLIDATED CAR HEATING COMPANY'S ELECTRIC HEATER.

THE fact that the passage of an electric current through a wire will heat it has been made use of by the Consolidated

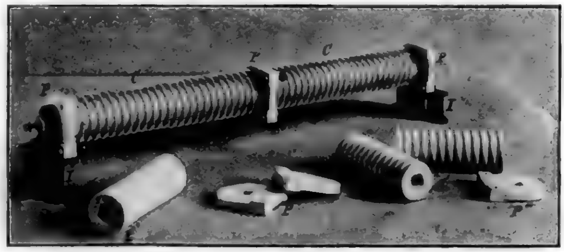


Fig. 1.

Car Heating Company of Albany, N. Y., for constructing a very convenient heater for electric cars, and for other purposes wherever an electric current is available.

The principle which governs the development of heat by electricity is stated as follows by this Company :

" The amount of heat given out is equal to the square of the quantity of current, measured in ampères, multiplied by the resistance of the conductor in which the heat is generated. The amount of heat given out by an electric heater placed between two conductors, in which a given difference of potential is maintained, therefore depends upon the resistance within the heater itself, and is, moreover, for a given difference of potential strictly proportional to the amount of current used."

In the heater, which is the subject of this article, the resisting conductors consist of iron wire .032 in. diameter wound on a mandrel $\frac{3}{8}$ in. diameter into helical coils. These coils are then wound on cylindrical glazed porcelain insulators 2 in. in diameter, which have helical grooves in them to receive the

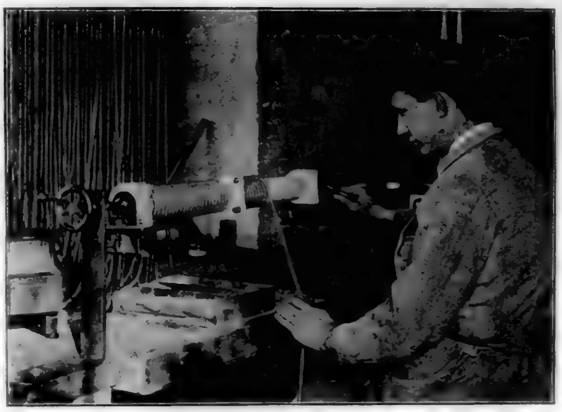


Fig. 2.

coils of wire. Some of these insulators, *C C*, with and some, *C' C'*, without the wire on them are shown in fig. 1. In fig. 2 the method of winding the coils on the insulators is shown. In this process the wire is drawn out sufficiently so as to prevent the neighboring convolutions of the wire from coming in contact with each other. The length of wire in a set of six heaters, a car equipment, is 2,550 ft., or nearly half a mile. The cores are mounted on a square $\frac{5}{8}$ in. iron rod, the aperture for which is plainly shown at *C' C'* in the detached cores in fig. 1. At the end of each core, which forms a division of the heater, a glazed porcelain plate, *P P*, is provided, in which binding screws are placed, to which the ends of the wire coils are connected. The cores are usually arranged in pairs, as shown in fig. 1, with a porcelain plate *P'* between them, so that the two sections may be connected independently if de-

Fig. 3.

sired. The porcelain insulators are supported by the iron rods referred to, which are carried at the ends on cast-iron stands *I* and *I*. These are fastened to the floor of the car. The heaters are covered with a neat wooden box or case, as shown in fig. 3, the cast-iron stands *I I* serving also as supports for the case, which has an open front protected by a wire screen. The case is lined throughout with asbestos mill-board.

In cars provided with paneled risers under the seats the heaters are placed within the risers, as shown in fig. 4, so that

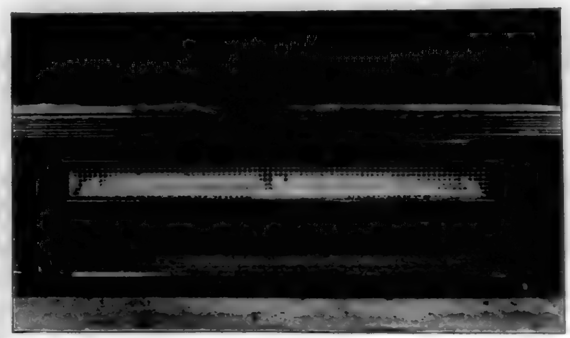


Fig. 4.

the front of the heater, with its grated openings, takes the place of the panel.

From figs. 3 and 4 it will be seen that the bottom of the wooden case stands a few inches above the floor. This allows cold air to flow into it where it is warmed by the coil, and then flows out through the grated opening into the car. The warm air thus communicates its heat to the feet of passengers before it rises to the upper part of the car.

In their descriptive circular the Consolidated Company say :

" To prevent the oxidation of the resisting conductor a galvanized wire is used which has the advantage of not oxidizing readily even when a high temperature is maintained. An

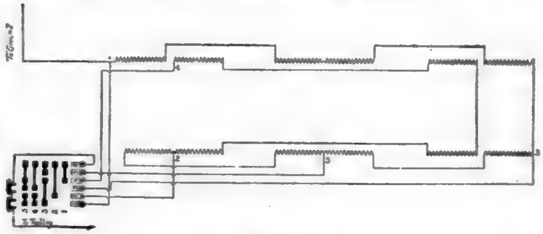


Fig. 5.

absolute assurance against any dangers from the oxidation of the conductor is secured by carrying in the resisting conductor a comparatively low temperature. To accomplish this, it is necessary to use a wire of considerable length, so that this wire may present a large heating surface and give off the desired amount of heat without the necessity for a high temperature. Neither in actual use nor in long-continued experiment has a heater failed from oxidation of the conducting wire. Should, however, a failure of the resisting conductor occur from accident or any cause, the coiled wire can be quickly and easily removed and a new wire be put in its place

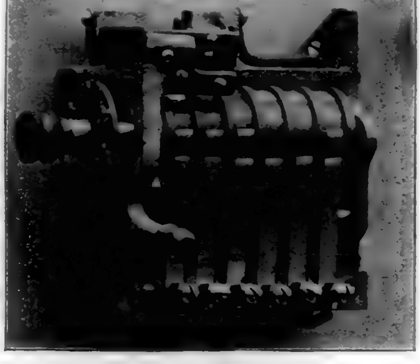


Fig. 6.

without even removing the heater from the car. But a few minutes are required to make a renewal of wire coil."

The Company also express the belief that when the thermometer is at zero, or below, that it will probably be necessary, during at least a portion of the day, to use about 12 ampères of current, if cars are effectively heated. Having determined the maximum amount of heat required in the coldest weather, the question then came up how to regulate the temperature in milder weather, so as to prevent the cars from being then overheated and a waste of electrical energy resulting in needless expense. The ability to vary and regulate the intensity of heat to meet the requirements of the weather was a necessary provision for a successful electrical heater.

In order to be able to regulate the heat, the heating coils are arranged as shown in fig. 5. An electrical switch, shown by fig. 6, is then provided which consists of a cylinder of insulating material which carries in fixed position on its circumference pieces of conducting metal. Proper connections of the metal contacts are made through the substance of the insulating material itself. The wires connecting the heaters in the several combinations necessary to obtain the different intensities of heat are connected to binding posts in the switch, and terminate in multiple spring contacts resting upon the surface of the cylinder carrying the contacts above described. The switch has six different positions. In one position the circuit is open (no heat), and the remaining five positions give different intensities or grades of heat. Different combinations of the electric heaters are made by the different positions of the switch, so as to increase or decrease the flow of current to correspond with the increase or decrease in the intensity of heat required.

In the first position of the switch all of the heaters are placed in series, so that the current from the trolley must pass through their combined resistance. In the second position one third of the total resistance is thrown out, the remaining two-thirds being placed in series. This results in an increase of about one-half in the intensity of heat. In the third position the switch recombines the heaters in a multiple series of two, thereby still further increasing the flow of current and obtaining a corresponding increase in the intensity of heat. In the fourth position the total heating surface is again recombined in such a way that one-third of the electric heaters is thrown out, and the remaining two-thirds are combined in a multiple series of two. In the fifth position the remaining one-third is thrown in, making a multiple series of three. The switch is inclosed in a neat wooden case not shown in our engraving.

The Consolidated Car Heating Company estimate that the additional cost incurred to generate the current necessary to supply electric heaters will be from one-half to three cents an hour to heat a car by this system.

PROCEEDINGS OF SOCIETIES.

Master Car-Builders' Association.—The Twenty-seventh Annual Convention of the Master Car Builders' Association for 1893 will be held at Lakewood, N. Y., with headquarters at the Kent House, commencing Tuesday, June 13, 1893.

There are two hotels near together, and the proprietor of the Kent House will receive all applications for rooms and locate the guests. His address is Jno. C. Brady, Kent House, Lakewood, on Lake Chautauqua, N. Y. The hotels agree to a uniform rate of $3 per day when nothing extra is wanted. Messrs. R. C. Blackall, T. A. Bissell, and Angus Sinclair are a Committee of Arrangements for this Convention.

American Railway Master Mechanics' Association Annual Convention.—The Twenty-seventh Annual Convention of the American Railway Master Mechanics' Association for 1893 will be held at Lakewood, N. Y., with headquarters at the Kent House, commencing Monday, June 19, 1893. There are two hotels close together, and the proprietor of the Kent House will receive all applications for rooms and locate the guests. His address is Jno. C. Brady, Kent House, Lakewood, on Chautauqua Lake, N. Y. The hotels agree to a uniform rate of $3 per day when nothing extra is wanted. Messrs. R. C. Blackall, T. A. Bissell, and Angus Sinclair are a Committee of Arrangements for this Convention.

Engineers' Club of Cincinnati.—At the last regular meeting of the Club Mr. E. F. Layman read a paper on Sidewalk Improvements in the Vicinity of Cincinnati, which comprised a review of the legislation enacted by the State of Ohio in the last few years pertaining to the construction of and manner of payment for sidewalk improvements, and a description of the proper construction, workmanship and materials necessary to secure the best results in building artificial stone sidewalks, which have been very generally adopted in the suburbs, an expenditure of $400,000 having been made on them in a few years.

Engineers' Society of Western Pennsylvania.—The February bulletin of the Society contains an article with a discussion on the construction and maintenance of the Howe truss bridges; also a short article on Segregation in Steel, by Walter E. Koch, who states that the method he has used for the last twenty years for the determination of sulphur in steel and pig iron is to take sulphuric acid, one part; water, four parts; mix, and when cold, pour on to five grammes of steel or iron in a flask, and pass the evolved gases into a cold saturated solution of cupric sulphate. In a few moments it will be possible to tell just how the sulphate stands. The method works better for steel than pig iron, but is very useful and quick for both.

Mr. R. N. Clark also contributed an article on the use of boneblack for domestic filters, giving the detail of his experience and the good results that have been obtained by the use of properly constructed bone filters.

Engineering Association of the South.—The regular monthly meeting was held April 13. The feature of the evening was a discussion on High Duty Attachments for Non-rotative Pumping Engines, led by Mr. L. d'Auria.

Mr. d'Auria showed that, apart from any consideration relating to expansion, the aggregate weight of the reciprocating parts in the Cornish engine is 2.3 times the weight of the load; in the Bull engine, equal to the load, and in the Worthington, one-tenth the load, though it could be made heavier without restriction; but, with reduction of weight in these three successive types of engines, the rate of steam expansion had also to be reduced, it being possible to use in the Cornish engine four expansions, in the Bull but two, while in the Worthington simple cylinder expansion was practically impossible.

Mr. d'Auria showed that the piston speed is affected by what he calls "effective weight;" this weight being expressed by the sum of the products of each of the reciprocating parts by the square of the velocity of its center of gravity or gyration, expressed in terms of the velocity of the plunger as a unit. In using steam expansively, this force in the first part of the stroke is greater than the load, and will perform an excess of work, "accelerative work." According to a law discovered by Mr. d'Auria, the mean plunger speed during the stroke in a non-rotative pumping engine equals

$$C\sqrt{\frac{\text{accelerative work}}{\text{effective weight}}},$$

the coefficient C varying with the variation of the propelling force, and in the average equaling about 4.8. By the application of this law, it was proven that the Bull engine could have been made lighter and yet used a higher rate of expansion than the Cornish, and that a Worthington engine could have been transformed into a high-duty engine by adding a reciprocating weight, about 7 or 8 per cent. of the load, and moving with a velocity four times greater than that of the plunger. This added reciprocating weight, which constitutes the D'Auria high-duty attachment, was shown in the form of a liquid column; thus, a direct-acting plunger is attached to an extension of the piston-rod of the pumping engine and moves in a cylinder of its own; at the ends of this cylinder the ends of a U-shaped pipe are attached, and the cylinder and pipe are filled with liquid. The area of the pipe being less than that of the plunger, the velocity of the liquid column is proportionally greater than that of the piston. Shocks due to excess of energy at the end of the stroke are prevented by passing the liquid around the plunger through small channels uncovered, when the plunger, by this excessive pressure, passes beyond its usual stroke. This feature, as well as the verification of the law of piston speed, was shown by a model in which the propelling force was a spring attached to one end of the plunger rod, the load being represented by a weight pulling at the other; these balanced only at the middle of the stroke, the pull of the spring at the beginning was about twice that of the weight, and at the end only equalled the friction of the working parts. When the apparatus was filled with liquid the piston made a steadier, longer stroke than when no liquid was used, showing the friction of the liquid to be insignificant. Diameter of the plunger, 3.94 in.; diameter of pipe, 2.06 in.; ratio of their areas, 3.65; weight of moving parts, 61 lbs.; weight of water in the pipe, 51.5 lbs.; hence the effective weight with the water is, $W = 61 + 51.5 \times 3.65^2 = 747$ lbs., and without the water is only $W = 61$ lbs. The accelerative work in both cases is $Q = 4.84$ foot-pounds, and the length of

stroke, 0.46 ft. The velocity was found to be with the water 0.383 ft. per second, and without the water, 1.33 ft. per second. According to Mr. d'Auria's approximate formula,

$$V = 4.8 \sqrt{\frac{Q}{W}},$$

the velocities equal 0.384 and 1.34 ft. per second respectively, showing close agreement with experiment. Besides, the figures show that the effect of the water in the pipe was to reduce the piston speed to about one-third that without water, and that without appreciable loss by friction.

Engineering Society of the South.—At the regular meeting held at Nashville on May 11, there was a discussion on the durability of Yellow Pine, in which Mr. Hunter McDonald stated that he thought yellow pine was not as durable now as formerly, ascribing as one reason among others the common practice of tapping pine for turpentine; also the fact that much of the timber comes from "old field pine," the secondary growth which has followed the clearing of the original forests. He thought the theory erroneous that tapping removed the turpentine from the sap only and not from the heart, and that the whole stick is made more porous for the absorption of moisture. Some bridge timbers were sound after 14 years of service, while nearly all pine timber now has to be removed in five or six years. He does not now paint wooden members of bridges, but houses them, allowing free air circulation. In the Tennessee River bridge at Johnsonville are timbers housed and sound after 21 years of use. He believes that if timber could be protected two years, then well painted, it would add four years to its usefulness. He finds more difficulty judging when a stick is unsafe from decay than in protecting it, and thinks some practical test of timber in place would be of great benefit.

Mr W. C. Smith agreed that timber when from original forests and not tapped lasted better than otherwise, and called attention to the hastening of dry rot by confining timber in walls. The confined ends of joists have rotted in nine months when the rest was still good. In his practice he either leaves air space around the ends of joists or builds projecting bearings for them. Poplar timber sawn from river rafts decayed in two years when exposed to the weather, and at the same time lasted well on interiors.

PERSONALS.

Mr. C. Ironmonger has been appointed Eastern Passenger Agent of the Seaboard Air Line, with office at 229 Broadway, New York.

Mr. J. J. Ryan, General Division Master Mechanic of the Southern Pacific, has been given charge of the entire Atlantic system of that road, including the ocean steamship service of the company.

Mr. F. Rosenberg, who resigned his connection with the Colorado Coal & Iron Company and the Bessemer Ditch Company of Pueblo, Col., on April 1, is now with Jutte & Foley, with an interest in the business.

Mr. A. E. Kendal has resigned his position as General Passenger Agent of the New York & New England Railroad, to assume the same position on the Old Colony Division of the New York, New Haven & Hartford Railroad.

Mr. E. P. Lord, formerly Superintendent of Motive Power of the Cleveland, Cincinnati, Chicago & St. Louis Railroad, has accepted a position as General Manager in charge of construction with the A. K. Porter Company, Pittsburg, Pa.

Mr. H. L. Gantt, late of the Midvale Steel Company, has been appointed General Superintendent of the American Steel Wheel Company, vice Mr. George W. Cushing, resigned. Mr. Gantt will have charge of the new plant at Garwood, N. J.

Mr. F. A. Scheffler resigned his position as General Superintendent of the Brush Company, of Cleveland, O., April 1, and has been appointed and accepted the position of General Sales Agent of the Stirling Company, manufacturers of the Stirling Water-Tube Boiler, with office at 74 Cortlandt Street, New York City.

NOTES AND NEWS.

The Rolling Stock of the Holland Railways is placed by the *Journal des Transports* at 715 locomotives, 1,833 passenger cars, and 9,860 freight cars. The annual service consists in the transportation of 22,185,182 passengers and 8,397,342 tons of freight, the ton-mileage not being given. The gross receipts for this service amounts to $11,985,422.83.

Signaling Direct to a Locomotive.—A method of signaling directly in front of the driver's eye is being tried on the Great Northern. Contact is made by a brush on the engine rubbing on a rail or wire. If a current is sent from the signal-box to the wire, the circuit is completed with the engine, and the little semaphore on the locomotive drops. Somewhat similar devices were shown at the Electrical Exhibition at the Crystal Palace 10 years ago, but they do not find much favor with railroad men.

Welding Steel.—The following process of welding steel is recommended in Germany: Heat in an iron vessel 64 parts of borax, 20 parts of sal-ammoniac, 10 parts of ferrocyanide of potassium, and 5 parts of colophony, all pulverulent, together with some water and a spoonful of brandy. Stir well; let cool in the vessel, and then stamp to a powder. The steel pieces to be welded are brought to a bright red heat at the weld-points, and the process is then conducted in the usual way with the help of the powder.

New Magazine Gun.—The new magazine gun invented by Lieutenant Henry K. White, U.S.N., has been completed at the Pratt and Whitney Works in Hartford and forwarded to Washington. The arm will be submitted to the Government Board, which has been ordered to reopen tests for magazine guns at Springfield, Mass. The system is what is known as "the straight pull," and the magazine contains five cartridges. Rim and "headless" ammunition can be adjusted for regular service with this arm. The inventor of the Durst magazine gun, who is now in Europe, is having a new gun made at Hartford, which will also be submitted to the Board for trial. The Durst gun was not completed in time for submission to the Board last summer.

Armor Plate Test for the "Texas."—A test, which resulted in the acceptance of 500 tons of armor plate for the *Texas*, was recently made at the proving grounds of the Bethlehem Iron Company by the representatives of the Government. It was a ballistic test. The test plate stood as a criterion of the redoubt armor of the steel armored battleship *Texas*, which is being built at the Norfolk Navy Yard by the Government. The test plate representing this important protective inclosure is 12 in. thick, 16 ft. long, and 8 ft. 4 in. high. It is perfectly flat and weighs 30 tons. This plate is composed of nickel steel forged on the big hammer and well tempered and annealed. Three shots were fired from the 8-in. gun. The missiles were 250-lb. Holtzen projectiles. The first shot was fired with a charge of 79 lbs. of powder, which developed a velocity of 1,678 ft. The projectile penetrated the plate, the tip just projecting on the other side, raising a rear bulge of about 2 in. The penetration was 14 in. The projectile rebounded and fell on the ground in front of the plate. The second shot was fired with a charge of 110 lbs. of powder, producing the extraordinary velocity of 2,004 ft. a second. The projectile penetrated the plate and backing. It did not rebound. The third shot, fired at a velocity of 1,835 ft. a second with 91 lbs. of powder, penetrated 15½ in. The projectile rebounded. All three were somewhat upset, but not broken. The points of impact were 28 in. apart. The plate endured the bombardment without damage, showing a remarkable resistance. It was not broken up in the least, nor were any radiating cracks developed.

Trans-Siberian Railway.—According to recent advices from St. Petersburg, work will be in progress during the coming season upon the following sections:

1. The Western Siberian Line, from Chelabinsk to the Obi River, 1,328 versts—885 miles—under charge of Chief Engineer Mikhailovski.

2. The Central Siberian Line, from the Obi River to Irkoutsk, 1,754 versts—1,170 miles—under charge of Chief Engineer Mejininov.

3. The Ekaterinburg-Mias Branch of 238 versts—159 miles—which will connect the Oural Railway with the systems of European Russia. This will also be under the charge of Mr. Mikhailovski.

The official programme adopted by the Ministry of Lines of Communication provides for the construction of the entire line from Chelabinsk to Vladivostok in 12 years. The pro-

gramme names the dates for completion of the several sections of the line as follows:

1. In 1894 the Oussouri Line, from Vladivostok to Grafskaia, and the Ekaterinburg-Mias Branch.

2. In 1896 the main line from Chelabinsk to Krasnoiarsk, including the entire Western Siberian Line and a portion of the central section.

3. In 1900 the remainder of the Central Siberian Line from Krasnoiarsk to Irkoutsk, and the extension of the Oussouri Line from Grafskaia to Khaborovka.

4. Finally, in 1904, the remainder of the main line from Irkoutsk to Khaborovka, including the Baikal loop, the Trans-Baikal Line, and the Amour Line.

The estimated cost of the entire line from Chelabinsk to the Pacific, 4,700 miles, may be given in round figures at $200,000,000.

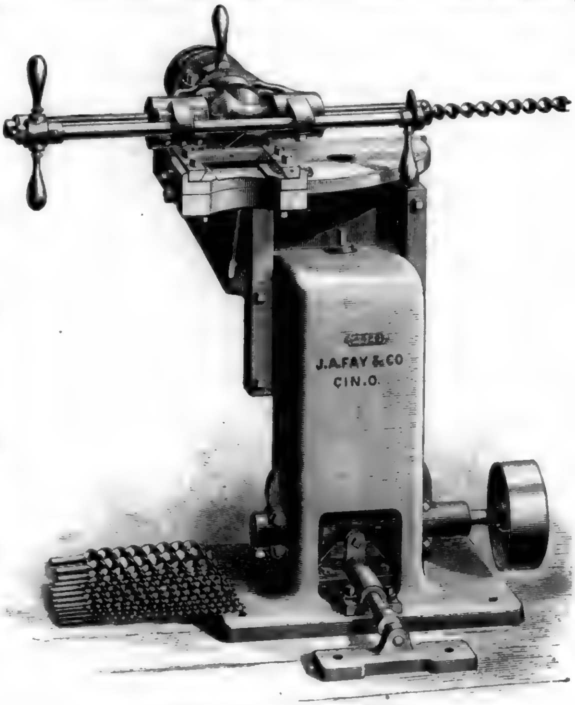
Manufactures.

RADIAL REVERSIBLE CAR-BORER.

The radial reversible car-borer, which is herewith illustrated, is one that is built by the J. A. Fay & Egan Company, of Cincinnati, O., and is especially intended for the end-boring of car sills.

It is so arranged that it will bore at any angle of a horizontal or vertical plane. The column which forms the base-plate of the machine is of one piece, and a boring-spindle runs in a revolving frame, which can be reversed so as to bore either to the right or left, and can be moved through an angle of 90°. It is attached to a segmental plate supported and gibbed to the column. The vertical adjustment of the boring-spindle and the table is obtained by means of a heavy screw driven by friction at the base of the column. There is also a hand adjustment which can be used if desired. The boring spindle has a vertical movement of 8 in. and a horizontal one of 12 in., and will bore to a depth of 1 ft.

The boring can be done in the end of a car sill or stick parallel with its length for joint bolts, and at right angles for ordinary bolts. It has been especially designed for use in connection with the automatic railroad saw, built by the same makers, so that by means of the two machines the two operations of cutting the ends of the sills and boring without changing their position are accomplished at the same time.



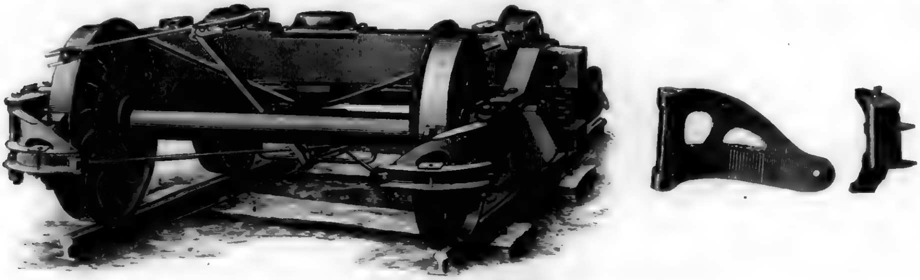
RADIAL REVERSIBLE CAR-BORER.

THE BEAMLESS BRAKE.

Statistics show that over 10 per cent. of the railroad accidents which occur in this country are due to detached brake-beams. They fall on the track and either derail some of the cars or detach more brake-beams, and thus produce what may be called a cumulative accident.

Having this danger in view, the Beamless Brake Company of 41 Dey Street, New York, and Bloomsburg, Pa., have brought out a truck which does not require any transverse brake-beams. This truck is shown by the engraving herewith. To each end of the truck side-frames a sort of bracket is attached by a vertical bolt, so that it can turn about the bolt like a hinge. These brackets are made of malleable iron, and, it will be seen, are curved inward from the end of the truck frame, so that they come opposite to and extend inside of the treads of the wheels. This bracket or curved arm or lever, as it may be called, has a corrugated inner surface, to which the brake-block is attached, so that it and the shoe can be shifted horizontally ¼ in. in either direction, and always be adjusted for a perfect fit on the wheel tread. Diagonal rods are connected to the inner ends of the brackets and are coupled to an equalizer and to the brake-levers. From this description, the operation of these brake-brackets will be apparent. If by any means they should be broken or detached from the truck frames, they would be less liable to throw cars off the track than a brake-beam is; or if a person should fall under a train or be run over there will be more room below the trucks, so that the cars could pass over him without injury.

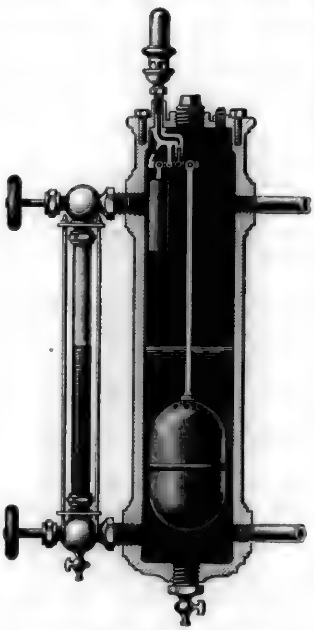
The brake-brackets are strong, simple and easy of access, to replace worn-out shoes, and can be seen easily by inspectors from the outside of the train. They are said to be perfectly noiseless, and have no vibration when in use, and the shoes have no tendency to "lop" over on the wheels when the brakes are not in use. No hangers or safety chains are required. A car with these brakes is on exhibition in the Transportation Building at the Columbian Fair.



THE BEAMLESS BRAKE.

ASHLEY'S COUNTERBALANCE LOW-WATER COLUMN.

The cut shows a low-water alarm for steam boilers, which in its operative principle is based upon the difference in weight of a body suspended in air and immersed in water. The alarm has the two connections to the boiler common to a water column, and is shown with gauge-glass attached. The cover of the alarm, which is fastened in place by tapped bolts, is removable, and to this is attached all the mechanism of the device. Suspended from the under side of the cover is a valve working in combination with a double-ended lever having its fulcrum between the two ends. From the ends of the lever two cylinders are suspended, the upper and smaller one of solid iron, and the larger hollow, with holes in its top, so that it is filled with water. When the water stands at the desired level in the boiler and column, the solid cylinder is heavier than the larger immersed cylinder, and consequently keeps the valve closed. As the water in the column falls, the hollow cylinder filled with water overbalances the weight of the solid cylinder when deprived of the buoyancy of the surrounding water, and opens the valve, admitting steam to the alarm-whistle. The solid cylinder regains its counterbalance on the admission of water to the boiler, closing the valve. This alarm, which is the invention of Frank M. Ashley, is made by the Ashley Engineering Company, Hawthorne, N. J.; New York office, 136 Liberty Street.



ASHLEY'S LOW-WATER COLUMN.

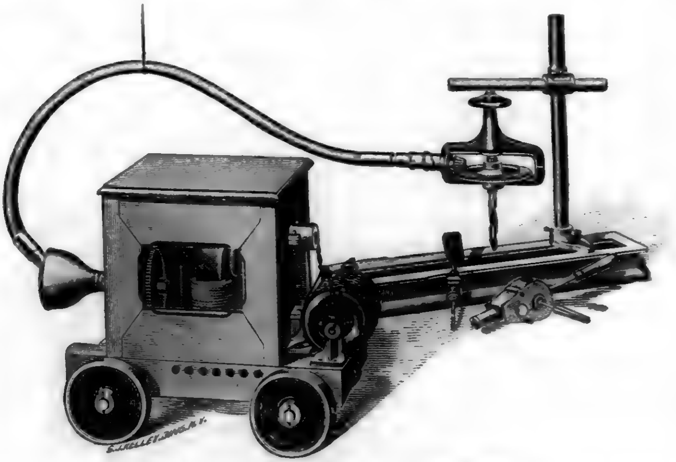
COMBINATION OF STOW FLEXIBLE SHAFT AND ELECTRIC MOTOR.

For nearly 20 years the Stow flexible-shaft has been on the market in connection with various other tools designed and manufactured by the Stow Manufacturing Company, of Binghamton, N. Y., for drilling, tapping, and reaming.

Thousands of them are in use in the various railroad, machine, boiler, and bridge shops in both this country and Europe.

There has been for the past few years among the larger shops a growing tendency to increase the range of this tool beyond that for which it was originally designed. This demand has been met, from time to time, by increasing the length of the driving rope and adding extra idlers for support of same, but the objection has been urged that when traveling cranes or other overhead machinery were used, that the driving rope was in the way. These objections are overcome by the use of the flexible shaft in connection with a specially designed low-speed electric motor. This combination has been under advisement for the past two years, and as a result an electric portable drilling, tapping, and reaming plant, that can, without trouble or loss of time, be carried to any distance from the source of power, is offered to the public.

The motor has a normal speed of about 600, which can be increased by a rheostat to 1,000 and 1,200, and reduced by gears to 275 without loss of power. These motors are manufactured for a voltage of either 110, 220, and 500.



STOW FLEXIBLE SHAFT AND ELECTRIC MOTOR.

TEST OF CUT AND WIRE NAILS.

A committee consisting of Charles L. Bailey, Arthur B. Clarke, and Horace P. Tobey, have made a report on the holding power of cut and wire nails. The tests were computed and arranged by Consulting Engineer William H. Burr, and were made on the United States Testing Machine at Watertown, Mass. The following is the substance of their report:

"At your request, I have examined, summarized and computed percentages upon the report of Major J. W. Reilly, of the United States Ordnance Department, giving in detail the tests made for ascertaining the relative holding powers of cut nails and wire nails, of equal lengths and weights; which tests were made at the United States Arsenal at Watertown, Mass., under the supervision of Major Reilly, in accordance with an invitation of the Eastern Cut Nail Manufacturers of the United States to the Wire Nail Manufacturers of the United States, dated November 4, 1892. The tests were made in November and December, 1892, and January, 1893.

"I find results as follows:

"The series of tests, each series comprising 10 pairs of cut nails and wire nails of one size, were, in number, 58.

"The number of nails tested was 1,160.

"The nails ranged in length from 1¼ in. to 6 in.

"The number of series in which the cut nails showed the superior holding power was 58.

"The number of series in which the wire nails showed the superior holding power was not any.

"All the nails tested were driven in spruce wood.

"Additional tests were made, of the box nails only, in pine wood.

"In spruce wood, in nine series of tests, comprising nine sizes of common nails (longest 6 in., shortest 1¼ in.), the cut nails showed an average superiority of 47.51 per cent.

"In spruce wood, in six series of tests, comprising six sizes of light common nails (longest 6 in., shortest 1¼ in.), the cut nails showed an average superiority of 47.40 per cent.

"In spruce wood, in 15 series of tests, comprising 15 sizes of finishing nails (longest 4 in., shortest 1¼ in.), the cut nails showed an average superiority of 72.22 per cent.

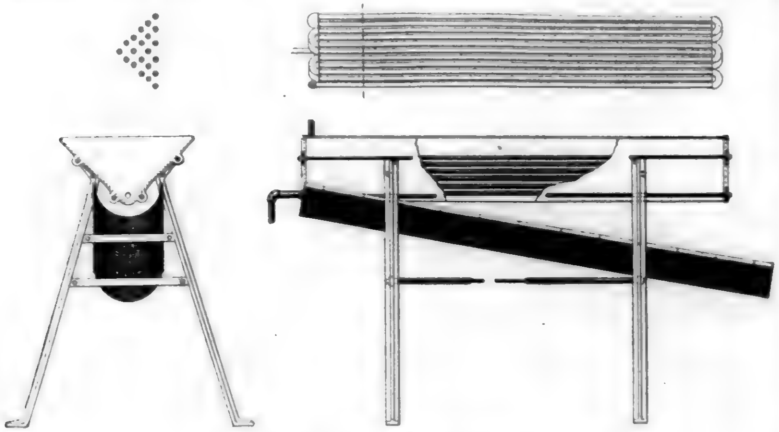
"In spruce wood, in six series of tests, comprising six sizes of box nails (longest 4 in., shortest 1¼ in.), the cut nails showed an average superiority of 50.88 per cent.

"In spruce wood, in four series of tests, comprising four sizes of floor nails (longest 4 in., shortest 2 in.), the cut nails showed an average superiority of 80.03 per cent.

"In spruce wood, in above 40 series of tests, comprising 40 sizes of nails (longest 6 in., shortest 1¼ in.), the cut nail showed an average superiority of 60.50 per cent.

"In pine wood, in six series of tests, comprising six sizes of

box nails (longest 4 in., shortest 1¼ in.) driven with taper perpendicular to grain of wood, the cut nail showed an average superiority of 135.20 per cent.



WILSON'S LOCOMOTIVE SAND-DRYER.

"In pine wood, in six series of tests, comprising six sizes of box nails (longest 4 in., shortest 1¼ in.) driven with taper parallel to grain of wood, the cut nail showed average superiority of 100.23 per cent.

"In pine wood, in six series of tests, comprising six sizes of box nails (longest 4 in., shortest 1¼ in.) driven in end of wood, the cut nail showed average superiority of 64.38 per cent.

"In pine wood, in above named 18 series of tests, comprising six sizes of box nails (longest 4 in., shortest 1¼ in.) driven in three ways, the cut nail showed an average superiority of 99.93 per cent.

"In spruce and pine wood combined, in the whole 58 series of tests, comprising 40 sizes of nails (longest 6 in., shortest 1¼ in.), the cut nails showed average superiority of 72.74 per cent."

LOCOMOTIVE SAND-DRYER.

The sand-dryer which is illustrated herewith is one which has recently been brought out by George P. Wilson, of 435 North Broad Street, Philadelphia. It consists of a long trough, in which there is a coil of steam-pipe, and into which the sand to be dried is placed. As the sand dries it falls down through the spaces between the pipes and out at a small opening in the bottom, from which it drops into the inclined wire screen shown in the engraving, which separates the sand from the coarser materials and through which the former falls ready for use in the sand box of a locomotive.

The device is so simple in construction that it needs but very little explanation, and requires no special attention except to be filled with sand when necessary. The dryer is set in a bin where the dry sand is to be sorted, and as the sand dries it falls through the screen into the bin ready for use, as already stated.

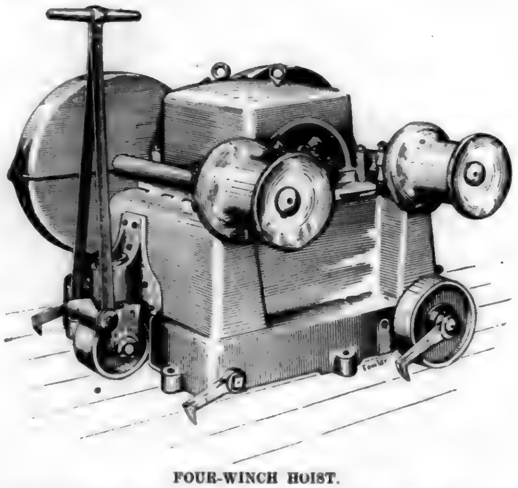
The apparatus is guaranteed to furnish dry sand for upward of 50 locomotives per day. In setting up, special precautions are taken that the steam-pipe is at the top of the coil. In outlying engine houses the steam hose of the locomotive may be attached.

THE FOUR-WINCH HOIST.

We illustrate a four-winch electric hoist, which has recently been perfected and brought out by the General Electric Company, for use on wharves and vessels. It has been designed to meet a growing demand for a machine which will satisfy the requirements of ship and dock work. The advantages which it offers over the usual form of steam hoist is that it is more compact, lighter, and does not require the attention of a skilled engineer. It can also be used in cold weather without that waste of power which results from the use of steam, where the condensation is great, owing to exposed pipes and unjacketed radiating surfaces. There are also no leaking or bursting pipes to give trouble. The four-winch principle which it embodies enables a number of loads to be raised and lowered simultaneously.

The apparatus illustrated consists of a base frame, a motor, two shafts, each carrying two winch heads, and the necessary controlling apparatus. The frame is a strong cast-iron box, open at top and bottom, and supporting on its upper rim the motor and winch-shaft bearings, each furnished with self-oiling mechanism. The frame is provided with wheels for convenience of application. The motor is of the latest design, and is entirely enclosed by its own frame, with the exception of two small lateral openings, which allow of ready access to the brushes and armature bearings, and which are closed when the hoist is in operation. It is so set in the hoist frame as to secure a low center of gravity and great rigidity. The field coil of the motor and winding of the iron-clad armature are covered with special water-proof composition.

The winch-shafts are of large diameter steel rod, to obviate the possibility of bending under heavy loads. The winch-heads are keyed to the shafts over bronze bushings, and the difficulties which rust might create forestalled. Each winch is provided with two safety pawls, which, when the hoist is in operation, are held out of action by centrifugal force, but which immediately catch into notches provided in the bearing cap, if the current fail while a load is being hoisted. This prevents overhauling of the hoist by the load, which might otherwise happen with disastrous results. The apparatus for controlling the hoist is placed below the motor within the frame, where it is protected from mechanical injury and moisture.



FOUR-WINCH HOIST.

The particulars and dimensions of this hoist are as follows: Four winch hoist, class 60-250, volts 110 (220) (500).

Net horse power of hoist at winches, 450 H. P.; normal speed of motor, 425 revolutions; voltage of motor, according to order, 500 volts; current at 110 volts, 300 ampères; total weight of hoist, complete, 8,000 lbs.

Lifting capacity of hoist, two weights simultaneously, 3,000 lbs; speed of lifting, 250 per minute; diameter of winch-heads, 12 in.; length of winding space on winch-heads, 9½ in. Over all dimensions of hoist are as follows: Length, 6 ft. 10 in.; width, 6 ft. 7 in.; height with wheels, 4 ft. 7½ in.; height without wheels, 4 ft. 5½ in.

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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NEW YORK, JULY, 1893.

EDITORIAL NOTES.

A REPORT is in circulation that a gun of 6.3 in. caliber and 47 ft. long has recently been tested in France that has given the enormous initial velocity to its projectile of 4,000 ft. per second. It is stated that the gun is not yet in shape for use on board ship, but that it is especially adapted for coast defense. The question that naturally arises is whether, with such a velocity, a material can be found that is sufficiently hard to enable it to pierce the armor that will be opposed to it.

A FEW weeks ago it was announced that the dynamite cruiser *Vesuvius* was doomed, that her guns were to be removed, and she was to be converted to a somewhat cumbersome gunboat. But there still seems to be a disposition to give the vessel all the benefits of the doubt, and it is probable that a further trial will be made, which it is intended shall be as conclusive as the Port Royal trials were expected to be. It will probably take some months to prepare the shells, and when this is done it is to be hoped that the cruiser will be given a trial that will stand on a par with fighting service.

THE French have certainly systematized the matter of universal expositions in a way that is worthy of the imitation of other nations. Already they are preparing for the great event of 1900, and while it may not equal the magnitude of the Chicago Fair, it will have the advantage of being thoroughly developed at all points, and showing the results of a careful and systematic forethought that is not everywhere apparent in the Windy City. Bigness is not necessarily completeness; and artistic excellence is usually the result of such long and careful preparation that its art appears to be natural.

THERE seems to be some ground for the complaints uttered in a recent letter to London *Truth*, in that steamship construction tends too much toward large and elegant saloons, with too little attention to the comforts of individuals in their state-rooms. Practically the saloons are only used at meal time, and that for a comparatively small portion of the voyage by the majority of the passengers, whereas the deck and the state-room are the abiding places of all but the gamblers, who frequent the smoking-room. The question is, therefore, very pertinently asked, whether it would not be better to curtail saloon accommodations a trifle and supply state-rooms with a few conveniences in the shape of wardrobes and drawers, in order that passengers may have more individual comfort, even though photographs of the main saloon may not show so great an extent of magnificence.

FROM time to time the question of oil burning as a fuel is brought to the front, and there are some enthusiasts who, regarding the matter from a purely mechanical standpoint, look forward to the millennium when coal heaving will be a lost art. But hard-headed calculators have shown time and again that the oil resources of the world are wholly inadequate to supply the demand for oil were it to supplant even a small percentage of the coal consumption. So the mere fact that the *James Brand* used oil instead of coal for fuel for three days on the last trip from England to Philadelphia simply proves, what every one already knows, that it is perfectly practicable to use oil as a fuel on locomotives, steamships, and stationary boilers, and that, whether it be used or no, it is merely a question of cost; and this has thus far kept the oil out of the field except in cases of limited application.

IF any naval architect of less prominence than Mr. J. H. Biles, the designer of the *Paris* and *New York*, had given voice to the opinion that a few years hence a thirty-knot speed would be maintained for ocean service, it would have been received with a smile of semi-incredulity. But coming from Mr. Biles it is deserving of the most careful consideration. Ten knots must be added to the present speeds. Of this Mr. Biles proposes to gain two knots by the use of nickel steel instead of ordinary steel; then three and a half knots by the use of oil instead of coal as a fuel, and the remaining four and a half knots he believes can be secured by such changes in dimensions as will increase the length and draft and by improving the machinery. The length will be about 1,000 ft. and the beam 100 ft., with a draft of 30 ft. The possibility of the vessel from a mechanical standpoint may exist, but there still remains the financial aspect to be considered; and the question at once arises whether such a steamship can be made to pay, and upon this alone will its ultimate construction probably depend.

WE have alluded from time to time to the proposed plan of using the trolley system for canal boat propulsion on the Erie Canal. We understand that arrangements have been practically completed for a trial, and that the power for the preliminary work is to be furnished by the Rochester Railroad Company. This certainly seems like the most sensible solution that can be given to the canal propulsion problem. These boats are of a comparatively small tonnage, and every foot of bunker space is valuable. Then the employment of a skilled engineer adds one, or, in case of night work, two, to the crew, which very materially increases the item of expense. But by the use of the trolley system there need be but three persons aboard. The drivers and mules are dispensed with, and the motor is under the control of the helmsman, so that a cook and two men are all that will be

needed for the safe and speedy navigation of the raging "canawl." Of course this means a big company for supplying power, and possibly the absorption of the individual owners until the State canal is turned into a private enterprise; but we need not cry "wolf" until we see him, especially when the advantages to be gained from the new system are so great.

COMPOUND LOCOMOTIVES.

The Chicago Exhibition affords an excellent opportunity of making a general review of the "state of the art" of the design and construction of compound locomotives. There are examples of nearly all the different types on exhibition, which thus admit of almost simultaneous comparison. There are a number of the two-cylinder type—that is, with a small high-pressure cylinder on one side and a large low-pressure cylinder on the other. The Brooks Locomotive Works have a four-cylinder tandem engine among those which they exhibit. The Baldwin Works are represented by a number of engines of the Vauclain type, having four cylinders, one high and one low, connected to the same cross-head on each side. The London & Northwestern Railway Company have sent one of Webb's three-cylinder engines with the two high-pressure cylinders outside and connected to the trailing pair of wheels, and a single inside low-pressure cylinder connected to a central crank on the front driving-axle. In the French department an engine like the one for the Paris, Lyons & Mediterranean Railway, which we illustrated last month, is exhibited. As shown by the engravings which were then published, it has four cylinders, the small high-pressure ones being outside the frames and coupled to the trailing driving-wheels, the axle of which is below the back end of the fire-box. The large low-pressure cylinders are inside below the smoke-box and connected to cranks on the front driving-axle.

This engine is worthy of careful study, and has some very decided advantages. There are many details which an American designer will not be likely to copy; but it is believed that the more it is studied the more there will be found to admire in its design. The details are worked out with a great deal of skill and are admirably proportioned, and any one with considerable experience in designing locomotives will see that whoever did this was a master of his occupation, even though the student of his work might not agree with all the features of the design.

The general plan of the engine has also much to recommend it if we want to use compound locomotives. To a person with what may be called fine mechanical sensibility there is something incongruous in the use of a great big cylinder on one side of a locomotive and a small one on the other. It looks, and is, lopsided. To incase the little cylinder so as to make them both *look* big is still worse, because this does not change the lopsidedness, but adds an element of humbug besides. A designer with the right kind of mechanical conscience would rather have his work look lopsided than to feel that humbug was employed to prevent it. Then, too, the enormous size of some of the cylinders which are on exhibition is objectionable. It would be difficult on many roads to get clearance enough for them, especially on six or eight-coupled engines on which they must be connected to the crank-pins outside of the coupling-rods. They are tremendously heavy, are difficult to make and to handle, and are liable to break. Their pistons and connections are correspondingly heavy and proportionately difficult to balance properly. The strains on the frames and connecting parts are increased with the size of the cylinders, although the increase may not be in the same proportion. This is also true of the tandem system; and the difficulty of balancing the reciprocating parts is as great or greater than it is on the low-pressure side of two-cylinder compounds.

In the Webb engine the low-pressure cylinder must be as large as it is for the two-cylinder system, and it is attended with the same difficulties that have been pointed out, excepting that, being located in the middle of the engine, its weight does not overhang, as it does when a cylinder is outside. The Webb high-pressure cylinders each require to be only half as big as they are on a two-cylinder engine. The difficulty of balancing is therefore lessened; but, owing to the fact that the front and back driving-wheels are not coupled on this engine, makes it impossible to use the adhesion of the front pair in starting if they should happen to stop at a dead point of the crank. The difficulty of balancing the Vauclain engines is, at any rate, no less than it is with those we have referred to.

Another feature of all these systems excepting Webb's—and it is true of simple engines also—is that the cylinder or cylinders on one side—whether it be one, as in the case of the two-cylinder engines, or two, as in the Vauclain or tandem type—at times must drive all the wheels which are coupled. In Webb's engine the high-pressure cylinders propel the rear pair of wheels, and the low-pressure cylinder turns the front pair. The front and back pairs of wheels are not connected together. The power and the strains are therefore divided. It has been pointed out that if the low-pressure crank should stop at one of its dead points, that its piston would be unable to exert any tractive power, and at a time when it is most needed. This must seriously diminish the starting capacity of these engines or add materially to the time required to start, which in some kinds of traffic is a matter of some importance.

Now, in our French four-cylinder engine none of these evils exist. The outside cylinders, which are for high-pressure steam, are of moderate size, because there are two instead of one of them, as in the two cylinder machines. The same is true of the low-pressure cylinders, and these are located between the frames when they are not likely to come in contact with any outside obstructions. Whatever advantage, if any, which inside cylinders have in being better protected from radiation of heat, their position gives them.

It will be noticed, too, that their steam-chest covers are outside, where they can easily be removed, thus giving convenient access to the valves and valve seats, the want of which is a serious objection to most inside cylinders.

The high-pressure cylinders, it will be seen, are connected to the back pair of driving-wheels, while the inside low-pressure cylinders are connected to cranks on the front driving-axle. The front wheels are thus driven by the low-pressure and the back pair by the high-pressure cylinders. The strains on the mechanism are thus divided, and its parts may be, and in this engine are, lighter than they are ordinarily on engines of this size. The coupling-rods have no work to do excepting to keep the two pairs of wheels in their proper relative positions. There is thus less strain on the parts and a consequent diminished liability to breakage.

It will be noticed, too, that the outside and inside cranks on each side of the engine are placed opposite to each other. The pistons of the high-pressure or outside cylinders on each side of the engine therefore move in opposite directions to

those in the low-pressure cylinders on the same side. This makes it possible for the reciprocating parts of the high and the low-pressure cylinders to balance each other perfectly, and gets over all the difficulty, be it great or small, which is attributed to this cause.

The high-pressure cylinders, too, are located about midway in the length of the engine ; and the low-pressure cylinders, being between the frames, the disturbing effect of the steam pressure on the movement of the engine will be much less than it is on any of the types of engine referred to excepting Webb's. The French locomotive ought, therefore, to be a very steady running machine. It will have none of the difficulties either of the Webb machine in starting heavy loads.

It should be noticed, too, that the large low-pressure cylinders are inside of the frames, where they are out of the way, whereas in the other four-cylinder engines they are outside ; and if the wheels are small, they come into inconvenient proximity to the ground and other obstructions.

The disadvantage of the French engine, which American engineers will be likely to object to, is the crank-axle. It is only the older living members of the master mechanics' fraternity who have had experience in the use of crank-axles in this country. The traditions of their experience still survive, however, and the younger members have inherited an aversion to them—we mean the crank-axles. In the present instance, however, something may be said in their favor. Considering the advantages which have been pointed out in the plan of the French engine, it may perhaps be reasonably asked whether past unfavorable experience with crank-axles should end all consideration of the plan by American engineers. Something may be said in defense of the crank-axle, and, in this case, some new evidence may be submitted in its favor. As has been pointed out, in the engine which has so much to commend it the crank-axle has only half the duty to perform that was expected of these organs in the old-fashioned simple four-coupled engines. In them the pistons turned the crank axles and the wheels on them. These wheels were connected to another pair by other cranks and rods. The crank-axle therefore had to perform double duty—that is, to transmit the propelling power from the cylinders to its own wheels and also to another pair, which were usually behind it. In the French engine each pair of wheels is driven by a separate pair of cylinders. The crank-axle is, therefore, subjected to only half as much of this kind of strains, and there would, therefore, seem to be less liability to breakage than there was in the crank-axles used a generation ago. The improvements and appliances used in metallurgy have given us in the steel which can be furnished for forgings to-day a material of greater strength than the iron possessed of which crank-axles were formerly made.

In other words, the question at issue is, whether the advantages which have been pointed out would outweigh the risk that we would now assume in using a crank-axle. That it is easy, in the waning light of past experience, to overestimate the latter is evident. It may be that practice which was impracticable a quarter or a half a century ago is quite safe now with the improvements in design and manufacture which have been pointed out. If there is no risk or difficulty in using a crank-axle for an engine of the general design which we have described, then, it is contended, we would have a more perfect machine than any other compound locomotive which has thus far been tried. It is true that there would be considerable extra cost involved if we compared such an engine with any of the other two or four-cylinder types in use. It would have, in the first place, a crank-axle, which is always more expensive than a straight one ; and there would be duplicate cross-heads, guides, connecting-rods, and valve-gear, although, if it is practicable to operate other four-cylinder compound locomotives with single valve gears, it would not seem impossible to do it with an engine of the general plan we have been discussing.

Our article has been written for the purpose of inducing American engineers to study the design of this French engine, the opportunity of doing which is afforded them at the Chicago Exhibition, and by the publication of the engravings of it in the June number of the American Engineer and Railroad Journal.

THE WORK OF THE MASTER CAR BUILDERS' CONVENTION.

The annual convention of the Master Car Builders' and Master Mechanics' associations have been held, and the members are once more scattered among their homes with recollections that vary according to the standpoint from which the individual member viewed the work at Lakewood. To those for whom the convention means an annual outing, with little regard for work, the funds supplied by the committee have given ample entertainment. It is difficult to conceive of a more delightful location than that of Lakewood, or a place where the charms of water excursions can be more fully realized.

There has, however, been some criticism, as we believe there always is, regarding the extent of the entertainment provided and the amount of the assessment levied from the attendant exhibitors ; and there is no doubt that a tax on each member of the "lobby" of $25 for each convention bears very heavily upon some who find it to their interest to attend these meetings. But when the early days of these conventions are remembered, and we revert to the wild go-as-you-please expenditure of some large firms, the present method of pooling the entertainment fund may be a good one, although there are differences of opinion as to the amount that should be collected.

Among the pleasant recollections, not the least will be that of the excursion to the stock farm of Messrs. Miller and Sibley, at Franklin. It is impossible, and might be somewhat out of place, to review all that was done ; but the enjoyability of the trip was greatly enhanced by the close attention to the minute details of the preparation that was apparent everywhere, evidencing the business methods that have made the stock farms themselves such a success.

The sessions of the convention were well attended, though the discussions did not appear to be so vigorous and spirited as they have been at times in former years. Of course the interchange rules were overhauled, but with one exception the changes aroused but little debate. That which attracted the most attention was Rule 19, which was so changed that any car which was originally equipped with a link-and-pin coupler is to be accepted, provided the drawbars fit properly, and is to be carded only for changes made in the rear attachments. This leaves a road repairing a damaged car free to use any drawbar that may be its own standard, without carding. The old rule required a card if the link-and-pin drawbar put in was not like the one originally on the car.

The Committee on Metal for Brake Shoes failing to report, a paper was presented by Secretary Cloud reviewing the

experimental work that has been done by the Pennsylvania Railroad looking toward the settlement of this question, and having in view :

"1. A comparison of retarding power with one brake shoe per wheel and with two shoes per wheel, with the same aggregate pressure applied to the wheel in each case.

"2. A comparison of retarding power with long and short shoes, with one brake shoe per wheel in each case.

"3. A comparison of retarding power with uniform pressures by the use of cast iron, composite, and three different grades of cast-steel shoes.

"4. A comparison of the durability of the cast iron, composite, and steel shoes in continued service; also, incidentally, the relative wear of the wheels under these different shoes.

"The tests were made on a uniform grade of about 80 ft. per mile, with three cars, two of which were passenger cars and the other a dynamometer car placed between the two. The three cars together weighed about 130,000 lbs. The run was made by gravity and the start by releasing the hand brakes on the forward passenger car, and on which alone the air brake was used to stop the three cars by opening the conductor's valve. The train of three cars was allowed to run a distance of one mile by gravity with the brakes released, and the time was taken by stop watches at the start and the end of one mile to check the uniformity of the speed attained in the different tests. On passing the one-mile post the air brakes were applied to the forward car only, with the other two cars pushing, and the time and distance required to make the stop were taken and the speed was recorded by the dynamometer car. The sliding of the wheels was noted by an observer at each end of the car which was braked. The condition of the rails was dry during the trials, but the wind, which was light, was in different directions and of different velocities on different days."

It was found that there was practically the same efficiency with the two methods of braking laid down in the first section, although it appeared that the wheels were more liable to skid with two shoes applied than when there was but one. It was also noted that the riding of the car was rather easier when two shoes were applied than when there was but one, "due, apparently, to the fact that the application of the second brake beam to each pair of wheels partly counteracted the tilting of the trucks caused by the outside suspended beams." The third tests resulted in giving to the cast-iron shoe the greatest resistance, though the percentage of area of wrought iron in the composite shoe was but 7 per cent., whereas with the shoe as usually made this area is about 40 per cent. In wearing qualities, however, the cast-iron shoe fell far behind, being about twice as great as the composite, and from six to fourteen times as great as that of cast steel.

Our readers will recollect the report on the same subject that was made in 1891, which embodied the more important of the results obtained in the laboratory of the Chicago, Burlington & Quincy Railroad. Road tests were recommended at that time, but a lack of funds stood in the way of carrying them out. The association has agreed to appropriate $500 for this purpose, however, and inadequate as the amount seems to be, it will serve as a starter, and we may hope to gather from the results obtained a more accurate knowledge of frictional resistances than we now possess.

The recommendations of the Committee on Axles, Journal-boxes, Lids and Wedges were confined, for the most part, to a revision of the present drawings, urging that they be re-dimensioned, and that these be made to agree.

Congress appears to have put things into something of a muddle by the recent law regarding the height of drawbars and the time clause, wherein the American Railway Association should make its recommendation. The old standard height of 33 in. has certainly not been followed very closely, chiefly, perhaps, through the influence of certain large roads which found it convenient to use a higher standard. It appears, from the report of the committee, that whereas 79.55 per cent. of the cars reported can have their draw gear adjusted to a height of 35 in., only 36.73 per cent. can be made 33 in. This is a strange state of affairs and one that certainly calls for a readjustment of the heights. The convention has, therefore, voted to submit the heights as promulgated by the Interstate Commerce Commission—namely, 34½ in. as a maximum and 31½ in. as a minimum—to letter ballot.

The tests of the M. C. B. couplers that have been made at Altoona and Watertown have resulted in the strengthening of many weak parts of couplers, and the determination of the most suitable metal to be used for the several parts. The tests showed that the malleable iron shank is amply strong to stand the yoke or tail-bolt strains of over 125,000 lbs., but that the pivot pins should be of high carbon steel, since wrought-iron pivot pins bent after a few blows so that the knuckle was inoperative.

In the discussion there were some rather sharp statements made relative to the use of malleable iron. This naturally excited outside discussion among the supply men who are interested in the manufacture of the metal. The statement to the effect that a great deal of the malleable iron that was manufactured was little if any better than low grades of cast iron was met by the argument that malleable iron should not be judged by poor qualities, but by what can be obtained, and that a guaranteed tensile strength of 35,000 lbs. per square inch can be had.

Among the recommendations which were made by the committee appointed to report on the protection of trainmen and lettering of freight car lines was one that there should be a handhold placed at the end of flat cars just below the flooring on the end sills and directly over the rails. This was strenuously opposed by some members both in and out of the convention on the ground that it added to the danger of the trainmen instead of removing it, inasmuch as it was so low down that, with the ordinary construction of diamond truck and inside hung brakes, it would be impossible for a man to keep himself away from the wheels by taking hold at this point, and that it would be better to have nothing than such a dangerous innovation.

The report on steel-tired wheels was very brief, and was presented almost entirely in tabular form. These tables consist of the weights and prices of the several steel-tired wheels which are now upon the market, and the objections which were raised by members to the spoke wheels. From the discussion which followed it is to be gathered that the general opinion of the members is that the steel-tired wheel is the proper wheel to use on passenger traffic, as would naturally be expected from the fact that it is almost universally used on the roads of this country. There were some objections raised on the ground that the wheels were apt to shear off parts of rails and that the tires were apt to break on account of improper backing on the part of the center, but these failures are so infrequent that they might be

almost entirely disregarded; still it is to be remembered that proper care must be taken in fitting the tires to the center and heating for shrinking on.

The report of the Committee on Steel Center Sills for Freight Cars was brief, but was quite extensively illustrated by drawings of the various designs which have been used abroad, and those of the Harvey Steel Car Company. The report stated that nothing has resulted from the experience of those using such cars in this country which would lead to a strong conviction for or against steel center sills. It has, however, been found on the Lake Shore & Michigan Southern Railroad that running repairs are much less with the steel under frames. The report dealt in a few words with the experience with metallic tender frames, and seemed to convey the opinion that they were not as desirable as the wooden frames on account of their liability to distortion in case of accident, as they cause a longer delay for locomotive repairs than would be the case were wooden frames to be used. The advantages that may be expected from the use of metal center sills lie almost solely in the increased durability and the reduced cost of inspection. A metal center sill, when it is properly constructed, is equivalent to a continuous drawbar arrangement from end to end of the car, and being composed of material having high tensile strength, steel center sills require but little inspection. It is, therefore, to be expected that the use of steel center sills will reduce the cost of running repairs.

This brief *résumé* of the work of the Master Car Builders' Association is a mere outline of what was done, and is simply the general impression that was produced by the reports, which will be published in full by the society in the course of six or eight weeks.

NEW PUBLICATIONS

PUMPING MACHINERY. *A Practical Handbook Relating to the Construction and Management of Steam and Power Pumping Machines.* By William M. Barr. J. B. Lippincott Company, Philadelphia (447 pp., 6 × 9 in.).

In his preface the Author says that "this book is essentially descriptive of pump detail; no attempt has been made to enter into the theory and mathematics of pump construction." He says further that "it has been prepared for the benefit of engineers, architects, contractors, plumbers, etc., who have occasion to recommend and use pumping machinery, and who wish to inform themselves regarding pump construction."

The illustrations have been made a prominent feature, and they are numbered up to 264. The Author says that, with few exceptions, the illustrations are from pumping machinery actually constructed and in use. Most of the engravings are evidently from original drawings, but in some few places the smudgy trail of "process" reproductions is apparent, as in figs. 149 and 161.

The introduction is quite brief, less than eight pages. The second chapter is on Water Pistons and Plungers, and is illustrated with 26 engravings showing different types of piston packing and plungers. The descriptive matter is admirably clear, and gives the kind of practical details which a mechanic is most interested in knowing.

The third chapter is on Piston and Plunger-Rods, and illustrates and describes various ways of fastening piston-rods to pistons. The last part of the chapter refers to stuffing-boxes, showing several different forms for fibrous packing. Nothing is said of metallic piston-rod packing, which is now much used in steam cylinders.

The fourth chapter is on Water Valves and Seats, and is illustrated by 49 engravings of different types of valves, and their construction and operation is fully described.

The other chapters are on Air and Vacuum Chambers; Suction and Delivery-Pipes; Water-end Design; Hydraulic Pressure Pumps; Steam and Power Crank Pumps; Direct Acting Steam Pumps; The Duplex Pump; Compound Direct-Acting Steam Pumps; Fire Pumps; Rotary Pumps; Centrifugal Pumps; Duty Trials of Pumping Engines; High Duty Pumping Engines—Direct-Acting and High Duty Pumping Engines—Fly Wheel.

With the exception of a few elucidations and demonstrations, there is no considerable use of mathematics. It is to be regretted that the author did not reduce all of these to arithmetical demonstrations or rules. With the exception of these mathematical parts—of which there are not many—the book can be easily read and understood by a mechanic whose education has not been extended beyond the three R's.

The book can be highly commended to all who want to increase their knowledge of the class of machinery to which it relates, and which is now so extensively used in all departments of the mechanic arts.

AMERICAN RAILROADS AS INVESTMENTS. *A Handbook for Investors in American Railroad Securities.* By S. F. Van Oss. (817 pp., 5¼ × 8¾ in.) New York: G. P. Putnam's Sons.

The subjects treated in this book are somewhat outside of those to the discussion of which the AMERICAN ENGINEER AND RAILROAD JOURNAL is devoted, and therefore it will only be described in a general way, but not reviewed.

Part I, the author says, "speaks of the rise of that unique conglomeration of lines which represents a nominal investment of upward of $10,000,000,000, and of its relations to the people and their government; Part II describes the position American railroads take in trade and travel, and discusses competition, rates, technical features, etc.; Part III sees the railroads in the light of financial ventures, of mediums for the useful employment of capital. . . . Parts IV to IX, inclusive, deal with the six leading groups of railroads. Each of them begins with a chapter describing an entire group and speaking of its characteristics as well as of the States it centers in, and further contains chapters devoted to the principal companies, while minor corporations are dealt with collectively. There are 39 chapters treating of 45 leading railroad companies, each giving an historical retrospect, a geographical description, a sketch of the progress and condition of the company, and elaborate tables covering a series of years and showing the development of the system, its traffic and earnings, as well as its capitalization, dividends, etc. Five colored maps are included in the volume; they illustrate the situation of every system and the competition to which it is exposed."

The author is a foreigner, and studied our railroad system at an angle of vision which is necessarily more or less indirect. Nevertheless he has studied our different railroad systems very carefully, and has brought together much valuable information and in a form that is easily understood. Chapter XXXIII, relating to the Chicago, Burlington & Quincy Railroad, may be taken as an example of his method. It begins with the date of the charter of the company, then describes the location of the road and extent and character of its traffic. This is followed by some remarks showing the competition which it must meet, the methods adopted to meet it, and the general condition of the property. After this tables are given showing the traffic, earnings, and expenses, balance sheet, and amount of capital stock, bonded debt, investments, etc., cost of construction, branch roads, and of uncanceled securities held in sinking funds. The chapter concludes with a statement of the

dividends paid from 1873 to 1892, beginning with 10 per cent. and gradually tapering down to 4½ per cent. last year.

Similar sketches of other lines of road—some longer and others shorter than this—are given, from which a tolerably good idea may be obtained of the past and present condition of the properties.

The maps are excellent, and we know of no other publication from which so good an idea may be obtained of the various systems of road in this country.

The book is printed in a sort of condensed pica type not often used in this country, but which is clear and easily read. One mechanical defect, which is very common in the books of the Messrs. Putnam and other publishers, is the small margin on the inside of the page. It is ample on the outside, where it is not of much importance. Reading from a sort of crevice in the middle of a book is very annoying. In the words of Herbert Spencer, "whatever [intellectual] force is absorbed by the machine is deducted from the result. A reader has at each moment but a limited amount of mental power available." If this, or part of it, is absorbed in the effort to decipher print where it cannot be easily seen, there is so much less remaining for the comprehension of the contained idea. The book before us would be very much improved if the type was placed ⅜ in. nearer the outside margins.

MUNICIPAL IMPROVEMENTS. *A Manual of the Methods, Utility and Cost of Public Improvements for the Municipal Officers.* By W. F. Goodhue, C.E. (129 pp., 5 × 7½ in.) New York: John Wiley & Sons.

There are people and books which we instinctively like on first acquaintance. The subject of this notice is a volume of that kind. There is nothing very attractive about its appearance, but after reading only a few pages the sound good sense which it contains at once captures the reader. We can't resist a quotation from the preface, in which the author says: "Once in every year throughout our broad land there are chosen, from among the citizens of every city and town, a number of councillors who will sit in the council chamber and assist the chief magistrate in the government of the municipality which they represent. The members of the council are perhaps familiar with the general plan and scope of the various public improvements contemplated during their administration, but of the details of the work proposed they are uninformed. It is in the nature of things that this should be so; their education and training have been in other work and its rewards. Yet, being men of affairs, they will not hesitate to seek such information regarding any proposed improvements as will enable them to discharge their official duties in a manner that will be commended by their constituents."

The Author does not say so, but his book is evidently intended for this class of people. It relates to sewerage, its cost and ventilation, the location of street-car lines, street sprinkling, street grades, surface, and pavements, street lighting and gas consumption, water works, municipal franchises, paving, bridges, assessments, fire limits, building laws and ordinances, building construction, the issue of municipal bonds, culverts, plans for a city hall, cleanliness, and public health. All these subjects are treated very briefly, but with admirable good sense.

Probably none of our readers who has ever had anything to do with municipal government will fail to appreciate the following remarks about street grades:

"Perhaps," the author says, "there is no other municipal improvement that will raise a longer and louder blast of indignation from property owners than the grading of a street. When such a job is under way the alderman who began it most generally wishes before the work is finished that either himself or that particular street had never existed, while the vocabulary of names having reference to imbeciles and other persons with little or no minds is exhausted and poured upon the head of the city engineer."

The benefits which would result if a copy of this book could be placed in the hands of every town and city councilman or alderman in the country would be incalculable. Take as an example the following hints about municipal franchises, of which the author says:

"A city granting a franchise at the present time should do so conditionally, and the conditions held in view should be:

"A re rating at stated intervals of prices paid for service rendered.

"The termination of the contract by purchase whenever desired, in a fair and equitable manner.

"Reserving the right to annul the contract when the service rendered is continuously inferior to the better service required.

"When a company seeks to obtain a franchise from a municipality, it does so because it is believed that the results of its operation will be remunerative, otherwise it would not be asked for, and this fact should be borne in mind, as it affords some idea of the value of the franchise asked for."

If a printed copy of these suggestions could be hung up in every council chamber in the land, it would result in a great saving to the public and prevent the granting of many wrongful privileges.

The book is full of useful hints with reference to all of the various kinds of municipal improvements treated of, and may be read with interest and profit by any one concerned in public affairs.

CLASSIFIED ILLUSTRATED CATALOGUE OF THE LIBRARY BUREAU. *A Handbook of Library and Office Fittings and Supplies.* Library Bureau, 277 Broadway, New York, 146 Franklin Street, Boston, 215 Madison Street, Chicago.

In the RAILROAD AND ENGINEERING JOURNAL for September, 1891, an editorial was published describing the extemporized system of preserving memoranda and papers which the writer had used for a number of years, and which was found to be a great help and convenience in doing editorial work. Although at that time we had some intimation of the applicability of this system, yet we did not realize the extent to which it might be used. We have now before us a copy of the catalogue, whose title is given above, showing the uses to which this system has been put of late years. This contains 175 pages, and illustrates a large number of the appliances which are furnished by the Bureau for use in the catalogues of libraries and for a great variety of other purposes. In one place they describe the card catalogue as a "series of cards properly ruled for their special use, of exactly the same size, and standing on the edge in drawers, boxes, or trays. They may be arranged alphabetically on any plan, by subjects, numbers or dates. Blocks, guides, cards, devices to prevent drawers from spilling or cards from being misplaced, locks and label holders and various other ingenious and almost essential accessories are now used by all who know of them. The great feature which has caused librarians the world over to count the card catalogue as the greatest library invention is the ease of keeping it up to date and in perfect order. A new card can be put into place anywhere at any time. A single reference takes the place of search through pages of manuscript. It never becomes out of date or useless. Anything can be removed, if wished, by simply lifting out its card. The guard allows cards to be added or withdrawn by the proper person with the greatest ease, but prevent others from removing or confusing their order. The cards, being cut by special machinery to an exact size, are turned through the fingers with great rapidity in looking up any matter, and the guides enable one to open very near the exact place at sight, and every card has the name, number, or subject by which it is arranged written on the upper edge. From an author's catalogue it

has spread to an almost infinite application. Every list, record, index, etc., that is in a state of growth can be thus kept with great saving of labor. Business houses find it invaluable for lists of goods, customers, discounts, and the thousand growing records of commerce. Science adopts it even more widely, and its use is spreading with growing rapidity. Each item being on a separate card, the whole may be rearranged over and over by simply shuffling into the new order. There is no copying nor waste of labor. Its enormous advantages once learned from use of a perfect outfit, it is sure to be applied to new uses."

It is said further that "every one who handles large lists of addresses or keeps in convenient order miscellaneous facts knows the great difficulties involved. Libraries recognized the difficulty in their work years before the great and growing records of commerce invented the card index, and discarded blank books for their indexes. Until recently its use has been confined to them, but somehow, with the customary avidity of commercial life, business men caught the idea, and without the influence of active propagation have to a wide extent adopted it.

"All the features that make it 'the greatest library invention' apply equally to commercial lists. Blank-book indexes with the wisest planning are sure to fill up irregularly, and never give perfect alphabetical arrangement for any list in a state of growth, while the card index can be maintained in absolute arrangement without limit to number of entries.

"Savings banks substitute it for the cumbersome and often to be rewritten blank-book index of depositors, and for recording signatures and points of identification; large manufacturing concerns use it in cataloguing patterns, drawings, keeping costs, etc.; insurance companies, for policy-holders' index and for statistics; railway systems, in keeping brief record of important points in their history, indexes to records, lists of employés; in fact, it is as great a labor saver to the business man as to the librarian."

One result of the great increase in the use of the card index by commercial houses has been the organization by the Bureau of a special department for writing, arranging and maintaining of indexes.

The Bureau not only undertakes this work, but sends its corps of experts to any locality, under the guarantee that the indexing will be done at less cost, more accurately, and the change from blank books to cards made without interruption of daily routine duties; in other words, a bank, municipal office, life or title insurance company, or any business house, may order its card index with no greater responsibility for results than in selecting and buying a desk or other office appliance, except to give the Bureau agent access to its records.

The special use to which we have put this system is in the care and classification of scraps, notes, and references. These may be most conveniently enclosed in envelopes, and the outside of them may be used for memoranda as conveniently as a card.

The Library Bureau now supplies all kinds of furniture, blanks, and supplies for keeping card catalogues of various kinds. These are made in a great variety of forms and sizes, and suited for all purposes. The increase of literature and knowledge of all kinds will make complete indexing much more essential in the future than it has been in the past. Without it our stores of knowledge will be useless, because they will be inaccessible.

BOOKS RECEIVED.

Hand-book of the American Republics, 1893. Bureau of the American Republics, Washington, D. C.

Description of the Lawrence Scientific School of Harvard University, Cambridge, Mass. Published by the University.

TRADE CATALOGUES.

New Process Balls, made by the Grant Anti-Friction Ball Company, Fitchburg, Mass., $3\frac{1}{2} \times 5\frac{3}{4}$ in., 8 pp. This little pamphlet is merely a brief advertisement of this Company, with a few letters commendatory of their products added. These latter are simply steel balls, which are made as nearly spherical as possible, and are then hardened. The title of the pamphlet leads one to hope that it contains more information than it does concerning the use to which such spheres have been put of late years.

Consolidated Car-heating Company, Albany, N. Y. Part XII., Electric Heater and Cable-Car Heating. $7 \times 10\frac{1}{2}$ in., 32 pp.

This company publishes its catalogues in parts. The one before us is on the subjects named. Their system of electric heating was very fully described in our last issue, so it need not be repeated here.

The latter part of the pamphlet is devoted to a description of the hot-water storage system of heating, which it is said is specially adapted for cable-cars, elevated railroad cars and other cars making runs of three hours or less. The system is adapted for heating any style of car where the runs are of such a character that a charging station can be passed once in about three hours, and a stop of one minute there be made for charging the heaters in the car. The distinctive feature of the system is water heat, stored in wrought iron pipes, conveniently placed in each car, and so connected that they can be charged with hot water under boiler pressure.

Catalogue of the Acme Machinery Company, manufacturers of bolt heading, upsetting and forging machines, Cleveland, O., $6\frac{1}{2} \times 9\frac{1}{4}$ in., 32 pp. This is a special catalogue of bolt-heading and forging machines, which line of tools this Company has lately designed and now manufacture in connection with their Acme bolt-cutters and nut-tappers. The frontispiece is a wood-cut showing a perspective view of the works of this Company. This is followed by engravings and descriptions of 1 in., $1\frac{1}{2}$ in., 2 in., $2\frac{1}{2}$ in. and 3 in. heading and forging machines; the figures meaning that the different machines will make bolts, upsets and special forgings of iron up to these diameters. These illustrations are followed by sectional views and descriptions of the construction and operation of these machines. Candor compels us to say that these can hardly be regarded as models of clearness. They show how rare it is to find a person who is thoroughly familiar with a subject who can place himself in the attitude of mind which a person who knows nothing about it occupies, and can then write so that the latter can understand what he is writing about. The author of the pamphlet before us is no doubt thoroughly acquainted with the class of machinery about which he was writing, but he has not, it is thought, made proper allowance for the ignorance- and stupidity it may be —of those of us who are readers of what he has written, but who are not experts.

The description of the machines is followed by a half-tone engraving showing the different kinds of work which has been done on these machines which is very interesting, and shows the range, so to speak, of the machines.

The volume closes with some interesting tables showing the amount of stock required to make square and hexagon bolt-heads, of manufacturers and United States standard sizes.

Illustrated Catalogue, Berry & Orton Company, Atlantic Works, Philadelphia.

There seems to be something about the business of making wood-working machinery which requires very elaborate catalogues. At any rate, there is no class of manufacturers who

publish such elaborate books to describe what they make as the makers of this class of machinery issue.

The book before us is 10½ × 7 in. in size, and contains 263 pages. The frontispiece is a wood-cut showing the works of this Company, which are on the corner of Twenty-third and Arch Streets in Philadelphia. This is followed by an introductory article, direction to correspondents, and report of the awards made to them by the United States Centennial Commission in 1876.

The catalogue itself begins with planing machines, of which there are 27 engravings and descriptions of different kinds made by this company. There are six different kinds of moulding machines, a panel raiser, several kinds of wood-workers, with two pages of diagrams showing the manner of operating these machines. There are 34 engravings of different kinds of circular-saw machines, and two of scroll saws, nine of band-saw machines. Fourteen pages and 17 engravings are devoted to band saws themselves and the tools and machines for keeping them in good order. There are nine engravings of mortising machines, six of tenoning machines, 12 of boring machines, a "gaining and crozing" machine, two cross-gaining and grooving machines, four moulding and shaping machines, five lathes, two sand-papering machines, five sash and blind machines, besides a number of miscellaneous machines, such as knife grinders, glue heaters, metal drilling and sawing machines, pulleys, etc.

The catalogue indicates the extent and variety of the business in which this Company is engaged.

From the same Company we have also received their 1893 Catalogues and Price-lists (3¾ × 5¾ in.), which has been thoroughly revised and rewritten, and contains 306 pages, 58 more than the preceding one.

Armington & Sims Engine Company, Providence, R. I., Catalogue of High-Speed Engines. 7 × 10 in., 47 pp. A novelty in this catalogue is an etching made from a photograph of the first high-speed engine which this firm connected directly to a dynamo. It is printed on buff paper and forms the frontispiece of the book. It is doubtful whether this kind of art can represent the sharp, clear and distinct effects so essential in representations of machinery as successfully as wood-engraving, which is as good as that on page 12 does, which was done by the John Andrew & Son Company.

The catalogue before us, after some preliminary remarks, gives a general description of the Armington & Sims high-speed engines. Its construction is shown by some excellent wood-engravings, and its operation is then elucidated by copies of indicator cards. An engraving on p. 12, already referred to, is one of the best examples of the wood-engraver's art, and represents a standard, single-cylinder, double-disk, self-contained, cut-off engine. Tables of sizes and indicated horse powers of this type of engines follow. A smaller engraving of a similar engine, but with a single disk and single wheel, with tables corresponding to those referred to for this type of engine is also given. These are succeeded by excellent engravings of the firm's cross-compound engines, with double disk, two wheels and self-contained, and tables of data relating to this type. A half dozen of engravings, made in white lines cut in a black background, represent different classes of vertical compound engines, and remind one of his early efforts at drawing on a slate. If we compare these with the engravings of a similar engine on p. 35, one is impressed with the feeling that the intagliated engravings are or should be an obsolete art. Excellent engravings of a tandem compound engine are given on pp. 32 and 33, and of some special engines on pp. 44 and 45.

The catalogue is beautifully printed on coated paper, and has an orange-colored rough paper cover, about the color of that of the American Engineer. The coated paper is beautiful to look upon and gives excellent typographic results, but, to paraphrase the old conundrum, it's like music—it-s-mell odious. This tepid joke is applicable not to this catalogue especially, but to all which are printed on this kind of paper.

The Standard Steel Works, 220 South Fourth Street, Philadelphia. 7¾ × 10¼ in., 68 pp.

In the preface to their new catalogue, a copy of which is before us, this Company say they "desire to put before you graphically two important steps which it has recently taken :

"*First.* A complete change in the form of the ingots from which 'Standard' tires are made, insuring clean, solid steel, free from piping or porosity, such as is liable to occur in tires made in the old way.

"*Second.* The addition to its tire plant of the hammers, presses, dies and machine tools necessary for the manufacture, in the best possible manner, and in large numbers of the Vauclain wrought-iron wheel center for engine truck, tender truck, and coach wheels."

The first "step" they illustrate by some half-tone engravings showing the form and size of ingots which they formerly used under their old practice, and that which they are now using. The first were cylindrical in shape, with a diameter of from 12 to 18 in., and from 12 to 15 in. long. The ingots which they are now using have a hexagon-formed section of from 12 to 20 in. diameter and about 5¼ ft. long. In another plate is shown one of the short cylindrical ingots and one of the long hexagonal cut longitudinally through their axes. This shows that each ingot has a honeycombed texture on top—they are both cast with their axes vertical—the longer ingot, as might be expected, having more of this spongy character than the short one. When the short ingots were used the porous part of it was hammered down and rolled into and formed part of the tire. To make their present method of manufacture clear, let it be supposed that the long ingot is divided into seven equal divisions in the direction of its length, and that it is then cut transversely at the first, third and fifth divisions. We would then have four pieces similar to the following :

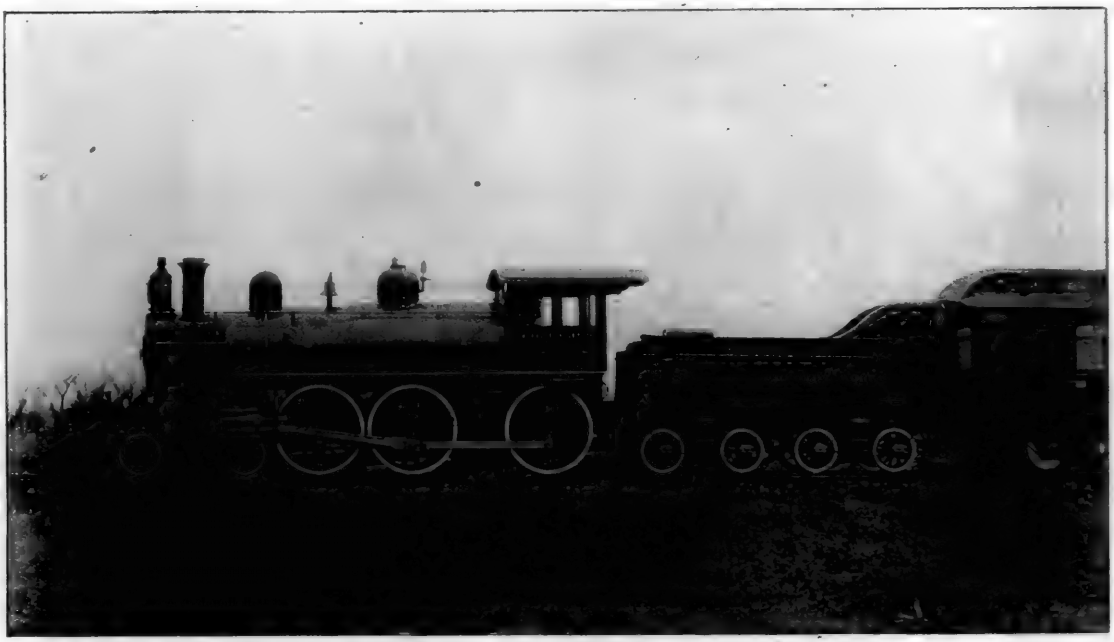
that is, there will be three billets each 18 or 19 in. long, and one short one of about half that length. The latter is cut from the top end of the ingot, and includes all the "piped" or porous metal in the ingot. This latter is thrown aside and scrapped instead of forming part of a tire, as it does when short ingots are used. The other three ingots will then consist of solid steel. The engraving showing longitudinal sections of a long and of a short ingot show the "piping" at their upper ends very distinctly. Another section shows the texture of one of the long billets into which the ingot is divided. Two other sectional views of tires whose grain has been developed by acid are given, one of them made from the old short ingots, and the other from one of the new billets. The difference in the homogeneity of the metal is very marked, and shows very much to the advantage of the new process.

The dissertation on tires is followed by a description of the Vauclain wrought-iron wheels and the method of manufacturing them. Half-tone engravings of the wheels, in different stages of manufacture and of their various parts, are given, and also outline engravings, made correctly to a scale, with all the principal dimensions marked on them, are added, for which many a draftsman will rise up and call the person who compiled the volume before us blessed.

Some excellent half-tone engravings showing exterior and interior views of the Standard Steel Works at Burnham, Mifflin County, Pa., are given in this catalogue, which is one of the best specimens of its kind. The printing, paper, presswork and binding are all very good.

COMPOUND LOCOMOTIVE WITH VESTIBULED TENDER.

We illustrate a ten-wheeled compound locomotive, *Columbus*, that is attached to the Pullman train exhibited at the World's Fair. This vestibule is for the double purpose of preventing the train over-riding or telescoping the tender in case of collision, and to prevent access to the train by train robbers should they succeed in stopping it. As to the first of these points the Pullman Company say that their experience has shown that the vestibule has practically eliminated telescoping from the results attending accident by collision or derailment, and that since its introduction the majority of accidents have arisen from the comparatively insecure connection between the tender and the train, there being nothing to prevent the front car from over-riding the tender. In our next issue we expect to give detailed illustrations of the tender and the vestibule.



VESTIBULED LOCOMOTIVE "COLUMBUS," AT THE CHICAGO EXHIBITION.

AMERICAN AND ENGLISH LOCOMOTIVES.

(*Continued from page 268.*)

Our illustrations of the various organs of the American and English express locomotives, which have been described in this series of articles, show the main connecting and coupling-rods of the two engines.

The following are the specifications of these parts for the Schenectady engine :

RODS.

Connecting and parallel rods of the best hammered iron, each forged solid, fitted with all necessary straps, keys, bolts, and Ajax metal brasses.

Parallel rods with solid ends, channeled bodies.

The English specifications are as follows :

CONNECTING-RODS.

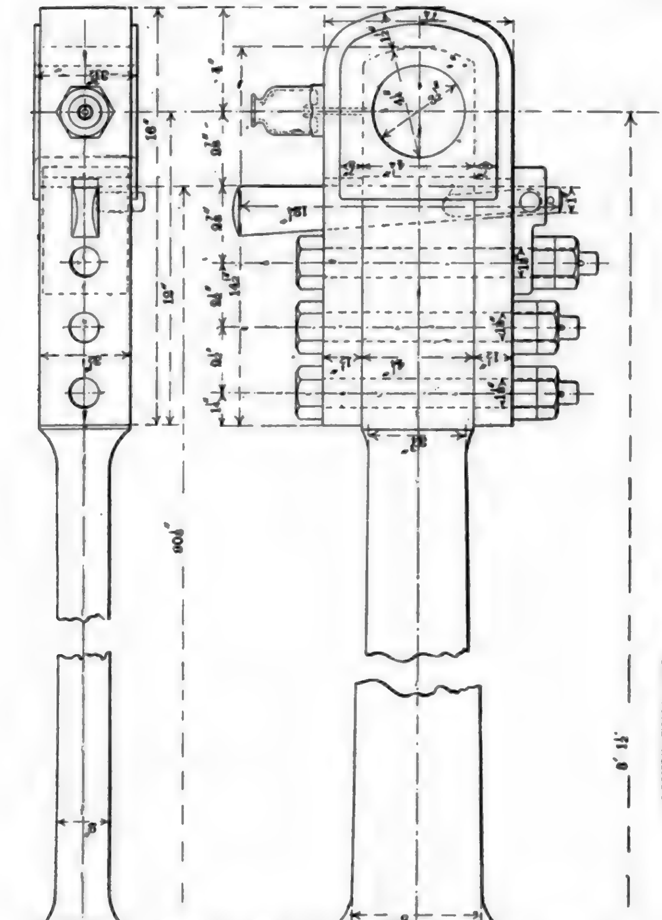
The connecting-rods are to be of the best Yorkshire iron, forged solid in one length, 6 ft. 8 in. from center to center, and are to be fitted with adjustable brasses of gun-metal at big end, and the small ends are to be fitted with gun-metal bushes accurately fitted and pressed into their places by hydraulic power. All bolts to be of best Yorkshire iron, and all cotters of mild steel ; the cotters are to be accurately fitted and provided with set screws and cross cotters. The brasses at the big ends are to be lined with white metal. Oil-cups are to be forged solid with the big end straps ; at the small ends a recess is to be made for lubrication.

COUPLING-RODS.

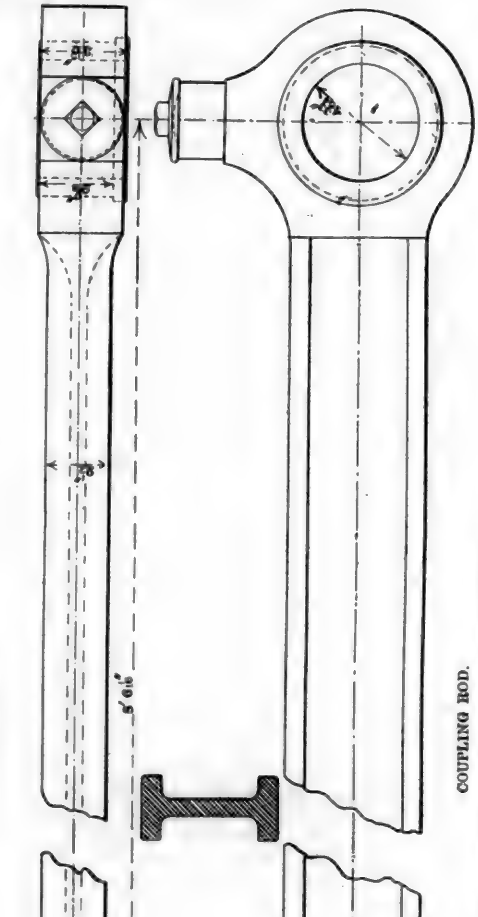
The coupling-rods are to be forged from best Yorkshire iron and machined out to form the H section ; the ends are to be accurately fitted with gun metal bushes, pressed into their places by hydraulic power, so as to ensure a perfectly tight fit, and to be secured as shown ; the bushes to have five grooves, $\frac{1}{8}$ in. wide and $\frac{1}{16}$ in. deep, fitted with white metal. All oil-cups for connecting-rods, coupling-rods, and eccentric straps to be provided with a button and spring, and are to be duplicates. The rods must be made in every particular as shown clearly on detailed drawing.

Not much comment on the different ways of making the connecting-rods in the two countries seems to be demanded. The only striking difference is that what our English brethren call the "big end" of the main connecting-rod is made with a solid forked end forged on it, with a bushing and bolt behind the pin to hold the forked end together. The front end of the rod, it will be seen, is forged with a solid eye and bushing. The American rod, on the other hand, has the old-fashioned strap "stub ends" for both the cross-head and crank-pin bearings. The straps are each held by these bolts.

The argument which is urged in favor of the forked end is that, being solid with the rod, and held together by a bolt of ample size, it is less liable to break than an old-fashioned strap is. On the other hand, Mr. Buchanan's reason for using the strap is that most of the work that must be done on a rod is on that portion in contact with the brasses. If a strap is used, nearly all the wear of the brasses is on it, and in making repairs a strap is much easier handled than a whole rod is. Facility of handling is therefore the argument in favor of the straps, and it is contended that if they are made of sufficient strength and properly secured to the rod they very rarely break.

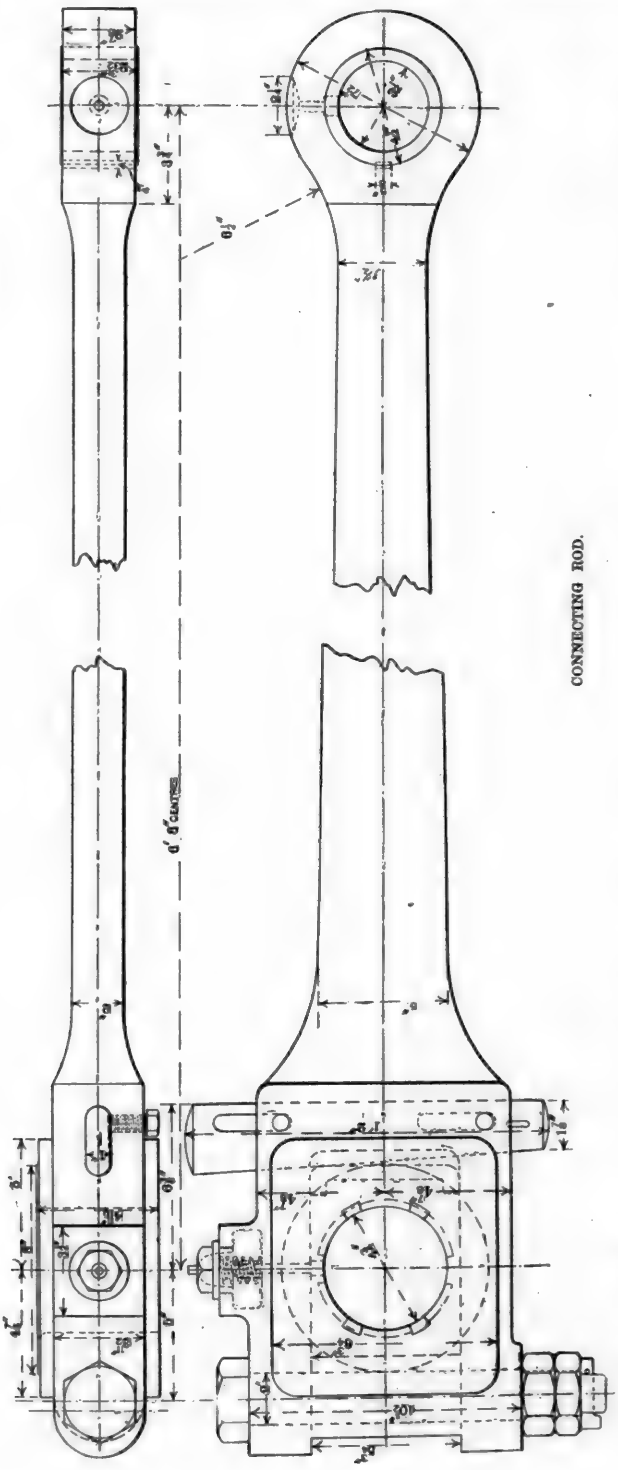


CONNECTING ROD.

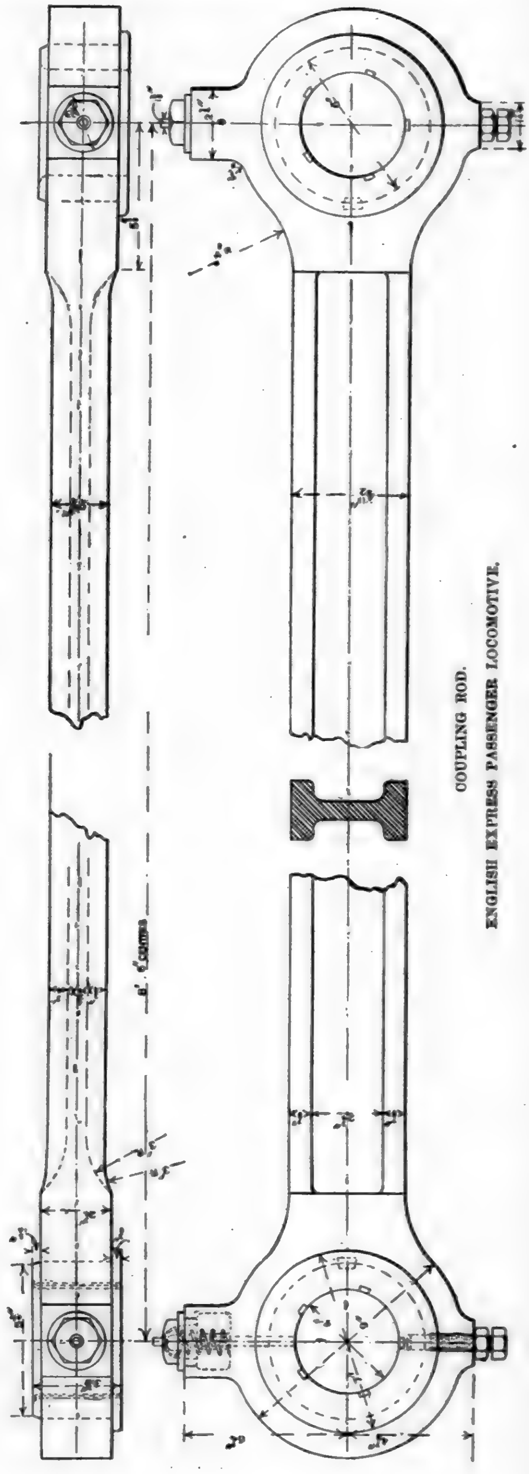


COUPLING ROD.

AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

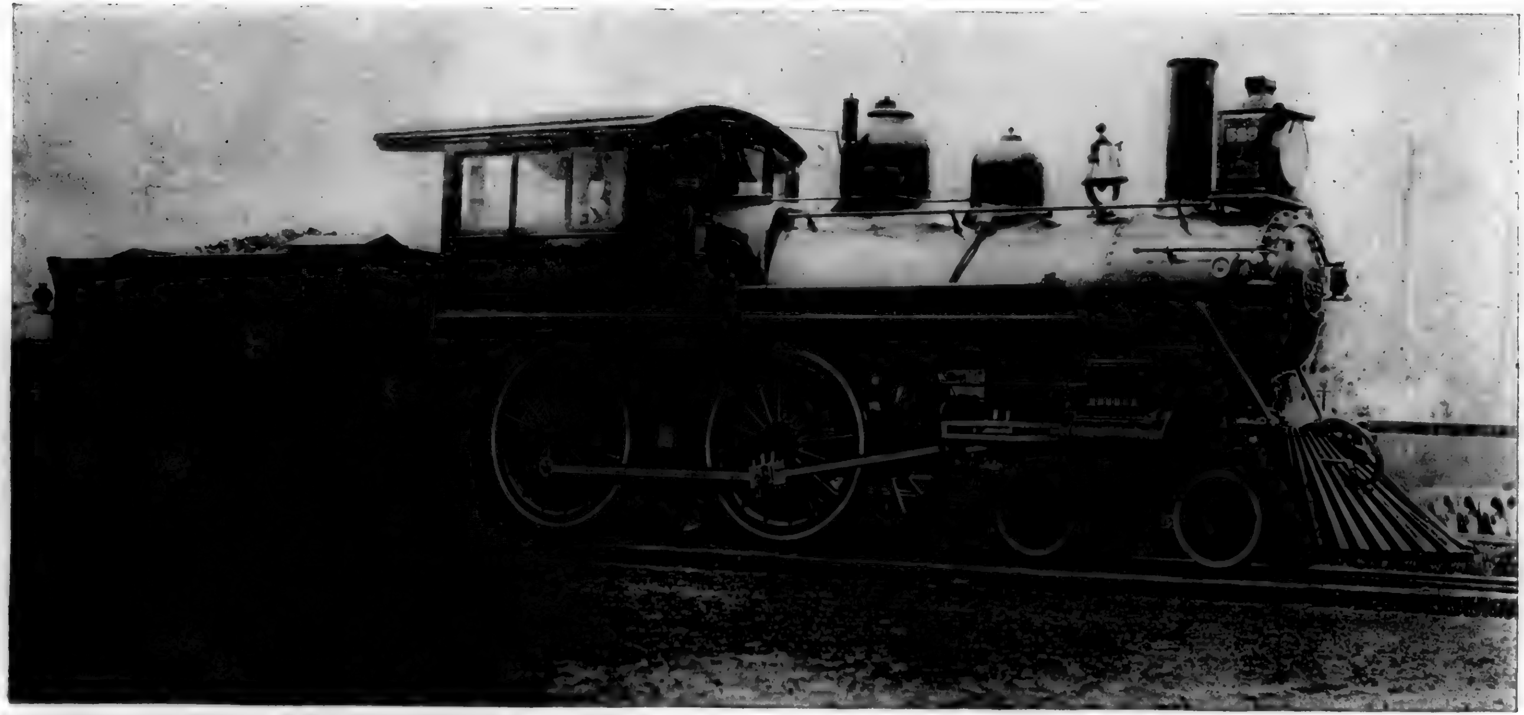


CONNECTING ROD.



COUPLING ROD.

ENGLISH EXPRESS PASSENGER LOCOMOTIVE.



FAST PASSENGER ENGINE HAULING THE "EXPOSITION FLYER" ON THE LAKE SHORE & MICHIGAN SOUTHERN RAILWAY. BUILT BY THE BROOKS LOCOMOTIVE WORKS, DUNKIRK, N. Y.

It is due to the Schenectady Locomotive Works to say that they make both kinds of rods, but Mr. Buchanan prefers the type which we have illustrated.

It will be seen that the size of the crank-pin bearing for the main connecting-rod on the American engine is 5¼ × 5¼ in., while that of the English engine is only 4¾ × 4¾ in. The diameter of the cross-head bearings is the same on both engines, but that on the New York Central engine is an inch longer than on Mr. Adams's machine.

The coupling-rod bearings are of the same length on each engine, but those on the American machine are 4¼ instead of 4 in. diameter, as on the English engine.

It will thus be seen, that although the cylinders of the English engine have 2 in. more stroke than those of the Yankee locomotive, the latter has considerably larger bearings for its connecting-rods. The English bushings for the coupling-rods are, however, 1 in. thick instead of ¾ in., as on the American rods. By comparing the dimensions of the two coupling-rods, it will be seen that the American rod is considerably heavier between its two ends than the English rod. It would be interesting to know whether any trouble has been experienced from the breaking of the lighter rods.

The oil-cups are all forged solid on the rods. Probably the same experience, of detached oil-cups, has led to this uniformity of practice.

FAST PASSENGER ENGINE FOR THE LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

Through the courtesy of the Brooks Locomotive Works, builders of the engine, we are enabled to present a full-page perspective illustration of the fast eight-wheeled express passenger locomotive which is now in use on the Lake Shore & Michigan Southern Railway, for hauling the Exposition Express over that line, and which is now making the trip from New York to Chicago in 20 hours, referred to in another column of this issue.

The general appearance of the engine is very clearly shown by our perspective engraving, and the peculiar feature to which we desire to draw especial attention is the boiler, of which we give a detailed engraving. This is of the Belpaire type, and its general dimensions will be found in the specifications which follow.

The general dimensions of the engine are :

GENERAL DESCRIPTION.

Cylinders, 17" diameter, 24" stroke ; driving wheels, 72" diameter ; gauge, 4' 8½" ; fuel, bituminous coal ; rigid driving wheel base, 9' ; total wheel base of engine, 23' 9" ; total wheel base of engine and tender, 45' 8".

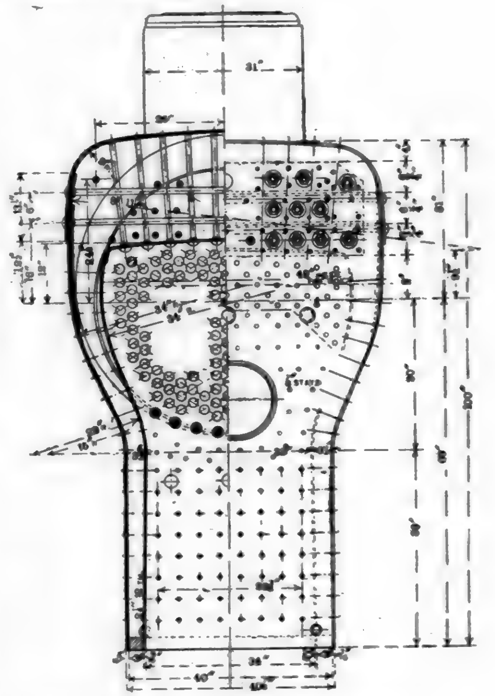
Weight of engine in working order	104,600 lbs.
" " " on engine truck	39,500 "
" " " " main drivers	33,100 "
" " " " back "	32,000 "
" " tender loaded	70,000 "

BOILER.

Type	Improved wagon top Belpaire with conical connection ; dome on connection sheet.
Working pressure	180 lbs.
Material	Steel, ⅝", $\frac{9}{16}$", ½", and $\frac{7}{16}$".
Riveting	Longitudinal seams, quadruple lap, without welt.
"	Circumferential seams, double lap.
Waist, diameter at smoke-box	52".
" " " throat sheet	60".
Tubes	200 in number, 2" diameter, charcoal iron.
"	Length, 12', No. 13 B. W. G.
Fire Box	78" x 34" inside ring.
" depth	81" at front end, 79" at back end.
" crown sheet	Arched, 1½" laterally in center.
Brick arch	Carried on three 2½" water tubes.
Heating surface	Fire box and arch pipes, 155 sq. feet.
" "	Tubes, 1,258 sq. feet.
" "	Total, 1,413 "
Safety vales	1 Richardson muffled and 1 Richardson plain.
Extension front	Deflector in front of exhaust pipe.
Stack	Cast-iron, straight, 16" diameter.
Exhaust pipe	High double.
Grates	Cast-iron rocking-bar.

MACHINERY.

Cylinders	17" x 24", 84" centers.
" packing	Dunbar.
Piston rod "	Jerome.
Valve stem "	"
Steam ports	1⅛" x 16".
Bridges	1⅛".
Exhaust port	3" x 16".
Valves	Allen Richardson.
" Allen port	⅜" x 16".
Valve, lap outside	1".
" " inside	$\frac{1}{16}$".
" lead in full gear	$\frac{1}{16}$".
" travel, maximum	6¼".
Eccentric travel	5".
Link radius	66".
" face	3".
" centres of eyes	13".
" block wearing face	5".
" " flanges	7¼" x 3¼".
" saddle pin	1¾" x 6".
" rocker pins, top and bottom	1¾" x 4".
Link hanger centers	18½".
" lifter arms, length	20½".
Reversing lever, multiple latch	Player's patent.
" " throw on top	42".
Driving wheels, diameter	72".
" " centers, diameter	66".
" " tires, Midvale	With Mansell retaining rings.
Driving axles	Hammered iron.
" " journals	7½" x 9".
Connecting rods, hammered iron, fluted	Fitted with straps and keys.
Coupling rods, Midvale steel, fluted	Fitted with brass bushings.
Crank pins	Midvale steel.
" " main	4¼" x 6".
" " " coupling	5¼" x 4".
" " " wheel fit	6¼" x 7".
" " back	3¼" x 4".
" " " wheel fit	4" x 7".
Frames, 46", centers forged solid	3¾" x 4½".
Frame, back end dropped down 5" to accommodate standard tender.	



Frame, pedestal ties	Player's patent.
Engine truck, four-wheeled	Swivelling spherical centre.
" " wheels	33", Allen paper.
" " axles	Hammered iron.
" " " journals	5" x 10".
" " springs	Detroit.
Driving spring rigging	Equalized.
" " auxiliary	Under rear spring hangers.
" "	Detroit.
Lubricator, cylinder	No. 9 Nathan triple.
Feed water	Two No. 8 Monitor injectors.
Oil-cups, rods and eccentrics	Adjustable spindle feed.
" eccentrics	Fitted with swab cups top and bottom.
" guides, etc	Adjustable screw feed.
Cab	Ash.
Cab fitted with three windows on each side, front stationary, middle and back to slide.	
Pilot	Fitted with shackle bar.
Brakes, train and tender	Westinghouse.
" drivers	"
Train signal	"
Steam-heating apparatus	R. R. Co.'s standard.
Headlight	" " "
Classification and signal lamps	" " "

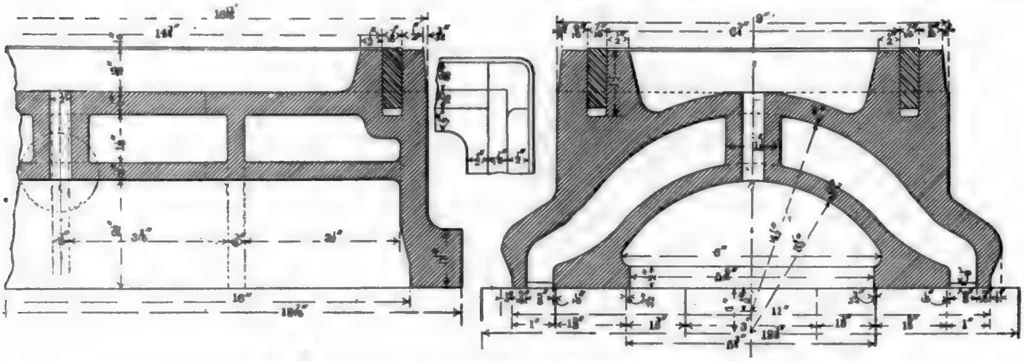
TENDER.

Frame	10" Channel steel.
Tank	and ¼" steel.

Tank capacity, water	3,100 galls.
" " coal	6 tons.
" water scoop	Improved Ramsbottom.
Tender trucks	Diamond pattern.
" " bolster	Steel I beam.
" " wheels	36" Allen paper.
" " axle	Hammered iron.
" " " journal	4" x 7".
" coupler and buffer	Gould.

We also give an illustration of the valve, the general dimensions of which are as follows :

Cylinders	17" x 24".
Boiler pressure	180 lbs.
Steam ports	1[illegible]" x 16".
Bridges	1[illegible]".
Exhaust port	3" x 16".
Allen port in valve	[illegible]" x 16".
Valve travel in full gear	6[illegible]".
" lap outside	1".
" " inside	$\frac{3}{16}$".
" " in full gear	[illegible]".
Eccentric travel	5".
Distance from center of axle to center of rocker	70[illegible]".
Link radius	66".
" centers of eyes	18".
" block wearing face	3" x 5".
" distance between faces	2[illegible]".
" block flanges	3[illegible]" x 7[illegible]".
" saddle-pin	1[illegible]" x 6".
" " off-set	[illegible]".
" hanger centers	18[illegible]".
" lifter arms, length	20[illegible]".



SLIDE-VALVE OF FAST LOCOMOTIVE FOR THE LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

One of the peculiar features of this valve is the enormous area of the Allen port used ; it will be noticed that with a lap of 1 in. this port is $\frac{5}{8}$ in. wide, having an overlap on the outside of the steam port of $\frac{1}{16}$ in. and $\frac{5}{16}$ in. metal at the wearing face on the outside ; this metal is reinforced to $\frac{9}{16}$ in. thick at a distance of $\frac{1}{4}$ in. above the face, so that there is no danger of breaking the valve on the outside of the Allen port.

Another feature is the amount of inside lap employed—in this case $\frac{3}{16}$ in. each side ; this, however, is a characteristic of all the Allen valves used by the Brooks Locomotive Works, and owing to the long travel employed, it does not result in excessive compression at the end of the stroke, as might be expected with shorter travel.

One object in the use of this amount of inside lap is that it permits the metal in the valve between the exhaust cavity and the Allen port to form a sufficient bearing upon the port face, thus preventing the hollowing out of the edges of the ports and edges of the valve, as is the case when Allen valves are constructed without having this additional bearing surface.

PATENALL'S IMPROVED SYKES' SYSTEM OF BLOCK SIGNALS.

By the Johnson Railroad Signal Company, Rahway, N. J.

(Copyrighted June, 1893.)

III.

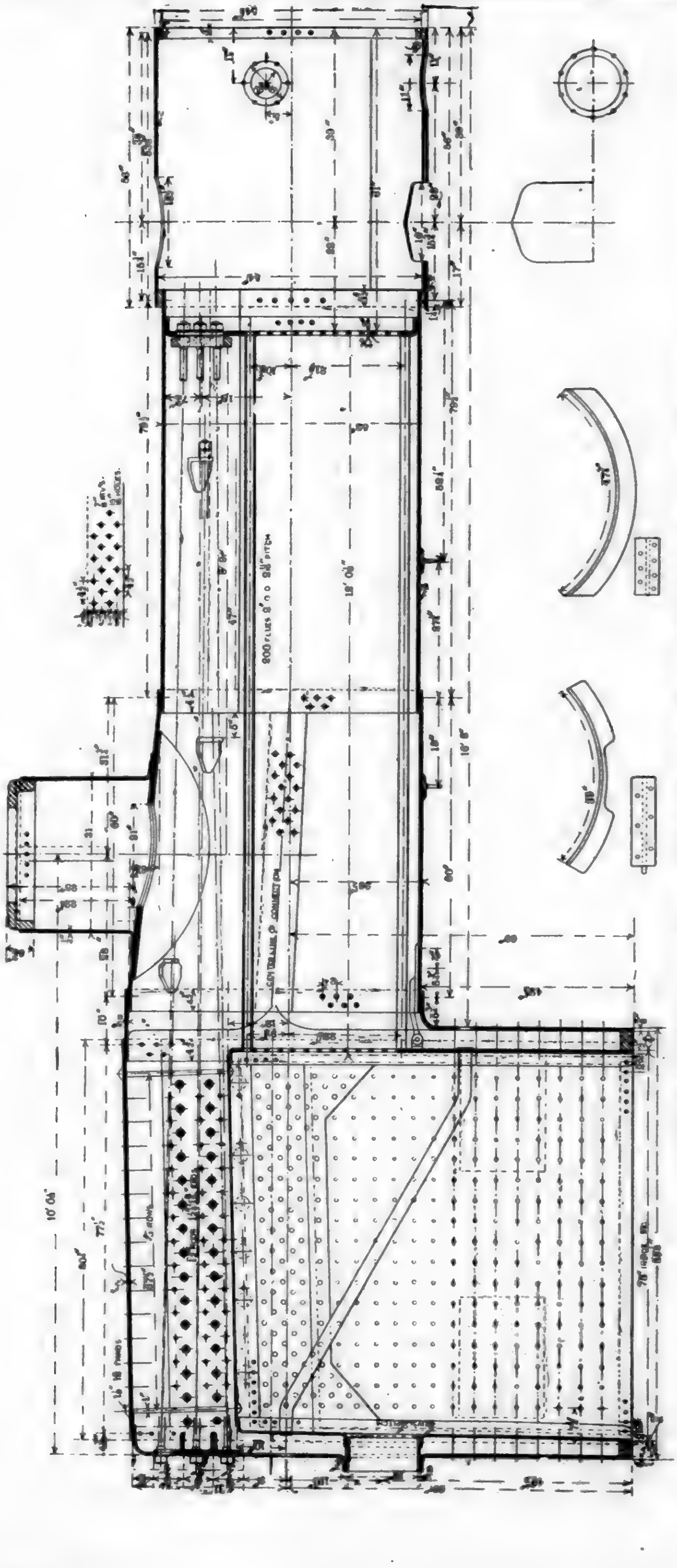
In the last number of this series of articles the general principles which are embodied in this system of signals was explained. In this one the mechanism in the indicator cases, by which the signals and the signalmen are controlled, will be described.

Fig. 20 represents a side view of the mechanism in one of the indicator cases, *R*, shown in figs. 5, 6, 7 and 9, published last month, and a section of the external wooden casing, *A A*, is shown in section in fig. 20. For convenience in representing some of the parts, they are shown as they appear in looking at the case from the opposite side from that in which it is shown in figs. 5 and 9. Fig. 25 is a similar view to fig. 20, but with some of the parts shown in different positions, as will be explained. Figs. 22 and 23 show views of some of the parts, which will also be explained later. Fig. 21 is a front view of the case, and shows its external parts. Fig. 26 is a transverse section of it, showing the internal parts.

A A, figs. 20 and 25, is the wooden casing of the instrument, which is of oblong rectangular form, as shown in the different views. Within the casing there is mounted a longitudinal sliding bar, *S' S*, the front end *S'* of which projects through the casing and is there provided with a latch, *S''*, which is hinged to the section *S'* at *b*, and is provided with an operating handle, *H*. The latch *S''* is also provided with a downwardly extending lip, *c*, adapted to engage with the lugs *a* and *a'* on the bracket *D* projecting from the front of the casing *A*, which thereby holds the bar *S' S* in the required longitudinal positions. A rocker *R* is pivotally connected at *d* to a support, *F*, at the bottom of the casing. A bearing, *e*, fig. 20, on the upwardly extending arm of this rocker is adapted to be engaged by a stud or pin, *e'*, on the side of the sliding bar, *S' S*, when the latter is drawn outward by the handle *H*. During this movement the stud *e'* comes in contact with the bearing, *e*, as shown in fig. 25, in which the bar is shown in the position it occupies when drawn out. This movement turns the rocker about its pivot, *d*. This has the effect of lifting the rod *C'*, which is connected at *f* to a horizontal projection on the rocker *R*. As the rod *C'* is connected with the dog, *k*, shown in fig. 10, published last month, it will be seen that the effect of pulling out the bar *S S'* is to unlock the latch of the lever, *L*, fig. 9, and make it possible for the signalman to throw it over and lower the signal. The upper portion of the rocker, *R*, figs. 20 and 25, is further provided with a straight bearing, *e'*, against which the stud *e'* will bear as the bar *S' S* is slid toward the right, and will thus return the rocker to its normal position, as shown in fig. 20, and thus by depressing the rod *C'* will again lock the lever *L*, fig. 9. It will be seen from fig. 20 that when the rocker has been moved so as to depress the rod *C'* that the stud *e'* is then free to slide horizontally above the straight bearing *e'* for a certain distance without moving the rocker. The object of this will be made apparent later on. It will be seen, though, that by pulling the handle *H* outward, and thus sliding the bar *S' S* in the same direction, the signalman unlocks the lever *L* of fig. 9, by which his own home signal is raised and lowered.

It remains to show how this operation of the signalman at any station is controlled by the man at the station ahead of him, the purpose of which provision has already been explained.

On its upper edge the bar, *S' S*, figs. 20 and 25, has an elongated notch, *b'*, and a shorter notch, *b''*. *M* is an electro magnet located above the bar *S' S*. Below this magnet a vibrating lever *G* is pivoted at *d'* to a suitable support *i*. This lever carries an armature, *f'*, which may be acted upon by the electro-magnet *M*. The lever *G* also has a pendent latch, *g*, pivoted to its outer end. This latch engages with the notches *b'* and *b''* whenever it is not held out of engagement therewith, either by the attraction of the magnet acting on the armature, *f'*, and thus raising the lever, or by being positively held up by a catch *k* on the lower end of *g'*. *g'* depends from a T-shaped lever, *h i' j g'*, which is pivotally connected to a suitable support at *i'*, and is counterbalanced by a weight *j*. The forwardly extending arm *h i'* of this lever is connected by a vertical rod, *h h'*, with an arm *a''* on the horizontal rock-shaft *K K* in the



BOILER OF FAST PASSENGER LOCOMOTIVE FOR THE LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

upper part of the casing. This arm is located at a'' in figs. 20 and 25, and is shown clearly in fig. 26. The shaft has an indicator plate B attached to its outer end. This indicator, and another on B', which will be referred to presently, occupy positions behind openings O and O' in an opaque plate, p' p', in the front of the casing. The indicators may be seen through these openings, as shown in fig. 21, and the indicating words or symbols may be read when the operating mechanism has been moved into the proper position to bring the indicating symbols into position. The plate p' p' is covered with a glass plate, G', through which the indicators may be seen.

The shaft K K is also provided with a counterweight, w, figs. 20 and 26, to counterbalance the indicator plate, B, and thus leave the shaft K free to be rocked by the movement of the lever h i' j through the connecting-rod h h'. The counterbalancing of the lever h i' j and shaft K K is so adjusted that the arm h i' tends normally to fall under the influence of gravity, and thereby swing the catch k to the right. If the lever G is then lifted by the attraction of the magnet M, the catch k will engage under the end of the lever G, as shown in fig. 20, and hold the latch g out of engagement with the notches in the bar S' S until the lever h i' has been raised and the catch k has thus been disengaged from G. Such movement of the lever h i' is effected by an upwardly extended cam J attached to the bar S' S, and adapted to engage with a roller r', which is carried in bearings depending from the under side of the lever h i' as the bar S' S is slid back and forth.

On the inside of the indicator casing a vertically sliding bar L L is held in position by bearings l l, see fig. 20, and is connected to the horizontally sliding bar S' S by a bell crank m n o'', shown by dotted lines in figs. 20 and 25. This bell crank has a fixed pivoted bearing at n, and is connected to a pin or stud, o, on the horizontal sliding bar S' S by an open-ended slot, and to another pin m on the vertical sliding bar L L by a similar connection. It will readily be seen that by means of this connection the horizontal sliding of the bar S will transmit a vertical movement to L L.

Near the top of the indicator case another vibrating lever r q s is pivoted to a suitable bearing or support at q, and is connected by a slotted end to a pin r on the vertically sliding bar L L. On its opposite end it has a forked end, s s', the form of which is shown clearly in fig. 23, which represents a plan or top view of this lever and contiguous parts. The end s s' consists of a pair of electrical circuit-making jaws, s and s', which are insulated from the arm r q s, but are electrically connected with each other by one or both of the fastening screws, s'' and s''. On the inside of the casing a contact plate P is secured in such a position that, as the vertically sliding bar L L is lowered and carries with it the end r of the lever r q s, and raises its opposite end, s, the circuit-making jaw s is brought into contact with the surface of the plate P', which is shaded with horizontal lines. On the opposite side of P', and separated from it and from each other by insulating material i'' i'', fig. 23, are two

Fig. 20.

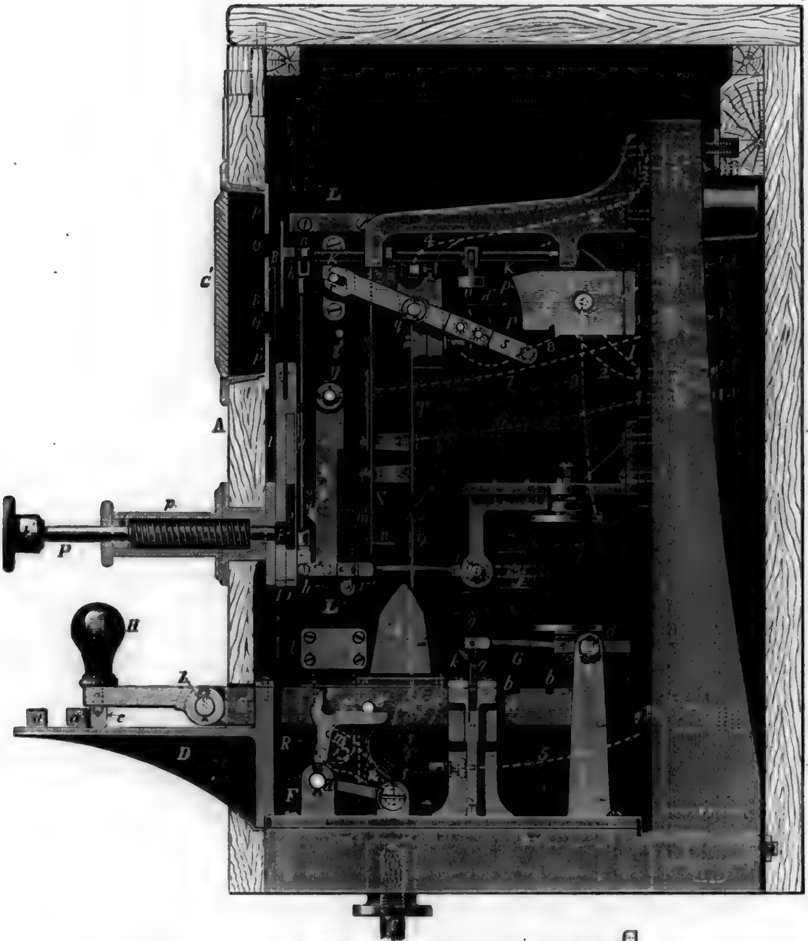
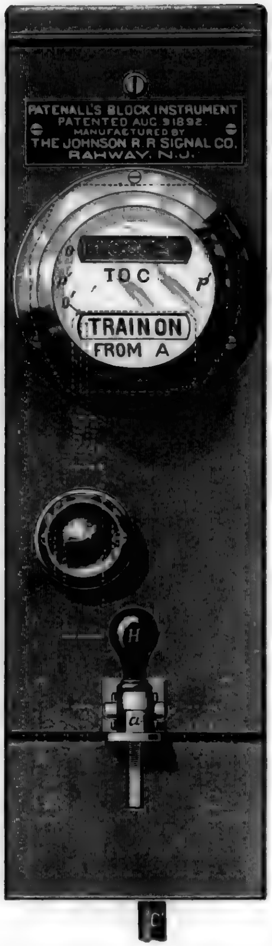


Fig. 21.



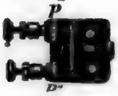


Fig. 22.

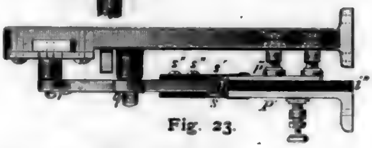


Fig. 23.

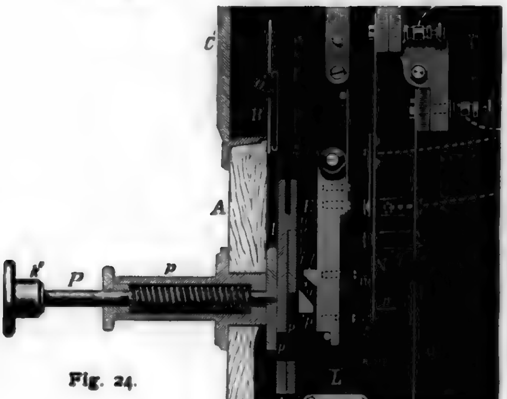


Fig. 24.

PATENALL'S BLOCK SIGNAL INSTRUMENT,

MANUFACTURED BY THE

JOHNSON RAILROAD SIGNAL COMPANY, RAHWAY, N. J.

Fig. 25.

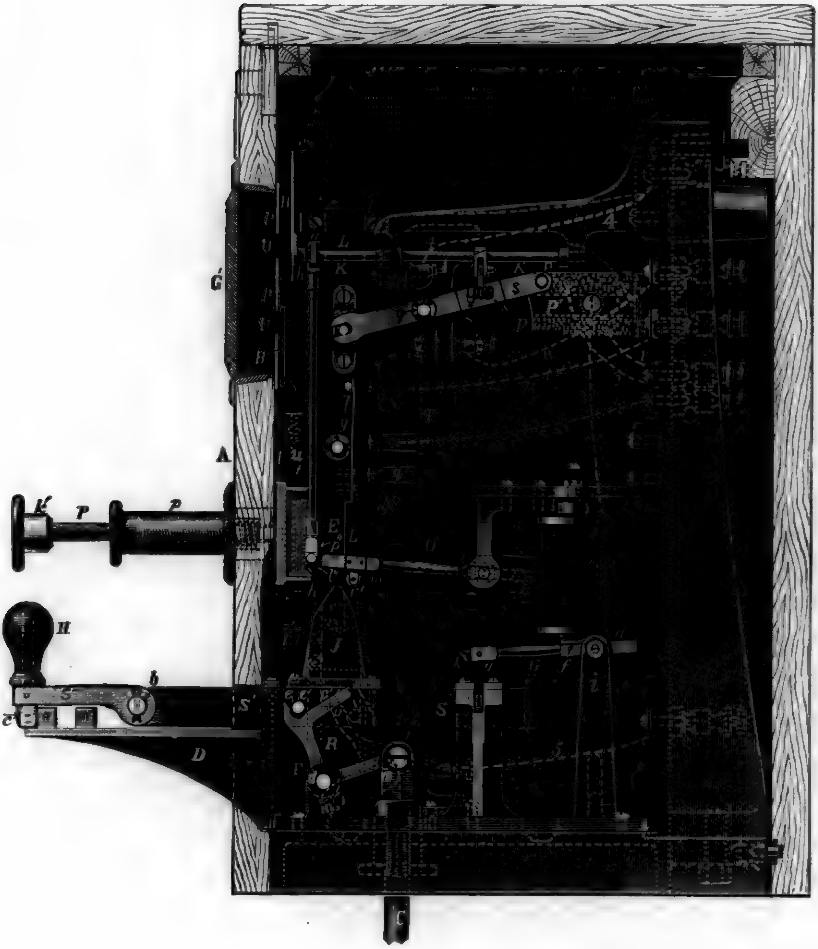
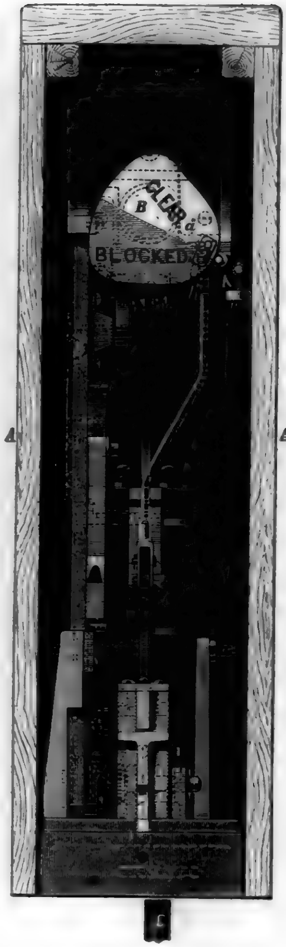


Fig. 26.



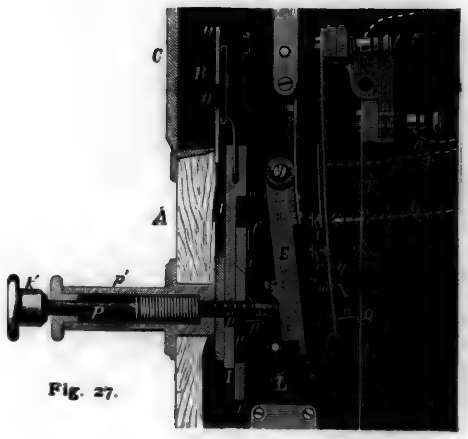


Fig. 27.

PATENALL'S BLOCK SIGNAL INSTRUMENT,

MANUFACTURED BY THE

JOHNSON RAILROAD SIGNAL COMPANY, RAHWAY, N. J

more contact plates, P'' and P''', see fig. 20. The form and position of these plates is shown in fig. 22, which is an end view of them looking in the direction of the dart d'' in fig. 20. In figs. 20 and 25 the contours of these contact plates are indicated by dotted vertical lines. By reference to figs. 20 and 25 it will be seen that when the vertically sliding bar $L\ L$ is lowered from the position shown in fig. 20, and the circuit-making jaws s and s' are raised, that s will come in contact with the plate P' and at the same time that s' will come in contact with P'', which is on the opposite side or behind P', as it appears in figs. 20 and 25. As the circuit-making jaws are electrically connected together, the contact plates P' and P'' will then also be similarly connected. If the jaws are raised still higher, s will still remain in contact with P', but s' will swing past P'' and will no longer be in contact with it, and electrical communication between the two plates will then be broken. When the jaws have moved far enough, or into the position shown in fig. 25, s' will then come in contact with the plate P''', and s and s' will then be in simultaneous contact, the one with plate P' and the other with plate P''', and electrical communication will thereby be established between them.

The plate P'' is in normal electrical communication by the wire 1 with the line-wire, which is connected with the next station ahead; the plate P''' is in permanent electrical communication by the wire 2 with a track treadle or circuit at the station where this instrument is located, and the plate P' is in permanent electrical communication by the wire 3 with the electro-magnet M for the purposes which will hereafter appear.

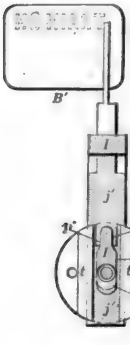


Fig. 28.

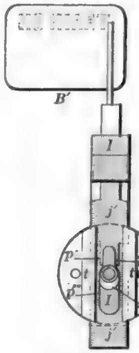


Fig. 29.

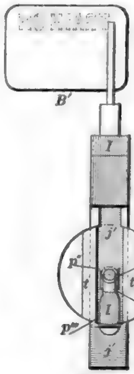


Fig. 30.

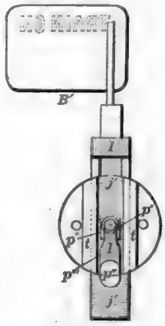


Fig. 31.

Before the operation of this instrument is fully explained, some other parts of its mechanism will be described.

The vertically sliding bar $L\ L$, figs. 20 and 25, carries a vibrating arm, E, which is pivoted to $L\ L$ at y. It is provided with a spring l', the tension of which tends to keep the arm normally swung toward the front of the indicator case. In front of each indicator case is what is called a "plunger," P, which is shown in section in fig. 20. It consists of a central rod or spindle P, which is housed in a cylindrical barrel, p, attached to the front of the indicator case. The outer end of the rod has a button or knob k' on it, by which it can conveniently be pushed inward. A helical spring is placed inside of the barrel, and bears against a shoulder on the rod or plunger, and thus tends to throw it outward to the limit of its movement. Within the casing and in the path of the plunger there is located a drop-plate, I, a back view of which, looking in the direction of the small dart on the right of p''', fig. 20, is shown in fig. 28, and which works in a slide, $t\ t$, attached to the inside of the case. To the upper portion of this drop-plate an indicator B', shown in figs. 20, 25, and 28, is attached. On its inside the drop-plate I carries a movable section, j', which can also move vertically in the slides $t\ t$ of fig. 28, so that it can fall a given distance independently of the plate I. The lower end of the vibrating arm E is located in the path of the plunger P, as shown in figs. 20 and 27, and is provided with a nose, l'', see fig. 24. The drop-plate j' is also provided with a nose, p'', corresponding to l'' and adapted to engage or interlock with it. Figs. 24 and 27 are views similar to figs. 20 and 25, but which show only the plunger, drop-plates, and contiguous parts, but in different positions from which they are shown in the complete figs. referred to last. The arm E is also provided with a block of insulating material, m', the nose of which is in position to engage a flexible electrical conducting strip, N, see figs. 20, 24, 25, and 27, depending from a suitable support within the indicator case, and carrying a contact pin, n', adapted to be thrown into and out of contact with an electrical conducting strip Q uprising from the lower portion of the casing. The strip N is in permanent electrical communication with the line-wire connecting the adjoining signal stations by means of the wire 4, and the strip Q by means of the wire 5 with a battery.

In order to make their form and operation clear, the plate I, in figs. 28 to 31, has been shaded with vertical lines, and j' has been similarly shaded with horizontal lines. The plate I is provided with an oblong opening p''', sufficiently large to give the plunger some clearance therein, but the opening is not elongated sufficiently to permit the plate I, when the plunger is inserted through it, to fall far enough so as to bring the indicator B' into a position in which the word TRAIN ON, inscribed on the indicator, can be seen through the opening O', figs. 20, 21, and 25, in the indicator face. The movable section j' has an opening p'''', see figs. 28 and 29, through it, which comes opposite or over the opening p''' in the plate I, but which is sufficiently elongated to allow the plate j' to fall when the plunger is inserted, as shown in figs. 27 and 30, a distance sufficient to allow the nose p'', fig. 27, to move downwardly past the nose l'' on the arm E. When the section j' has reached this position, the withdrawal of the plunger, as shown in fig. 24, will permit the arm E to swing toward the front of the indicator case, and, as shown in fig. 24, will carry its nose l'' above the nose p'' on the section j', and thereby permit the drop-plate I and its movable section j' to fall the whole limit of their downward movement, as shown in figs. 24 and 31, and thus bring the indicator B' into a position behind the opening O' to show the words "TRAIN ON," which are inscribed on it. If the plunger be only partially withdrawn so that it still remains within the opening p''', fig. 27, in the plate I, then the section j' will fall far enough past the opening p''' so as to prevent the plunger from being again pushed into contact with the arm E until the plate j' has again been raised to its normal position. The plate j', fig. 20, is held up in its upper position by the engagement of the nose l'', on the arm E, under the nose p'' on the plate j'. As shown in figs. 24 and 27, the upper end t' of the plate j' engages with a projection u on plate I and thus holds it up. After the plate j' has once been lowered, it can only be raised by lowering the bar L, which is done by the outward movement of the knob H and bar $S\ S$. This brings the nose l'', on the arm E below the nose p'', see fig. 25, so that they can engage with each other. In order that the nose l'' may ride past the nose p'', and that the forward movement of the arm E will exert a downward pressure upon the movable section j', the upper side of the nose p'' and the lower side of l' are provided with beveled or inclined faces x and y', as shown clearly in fig. 24.

For the purpose of utilizing a single line-wire for connecting the instruments for moving the trains on both the incoming and outgoing tracks, a connecting strip, T, see figs. 20 and 25, is provided in permanent electric connection by a wire, 6, with the contact plate P'' of the companion instrument at any station, and normally connected with the line wire leading to the adjacent station by means of a connecting arm, q', carried by the depending strip T. When the strip N is swung inwardly, as shown in fig. 27, under the impulse of the plunger, the spring N will be disengaged from the arm q', and the circuit through the companion instrument will thus be broken while the circuit through the electro magnet at the next preceding station is closed.

The description of the operation of this instrument must be reserved until next month.

(TO BE CONTINUED.)

Electrically Welded Steel Barrels.—A large industry is being built up at Barrow, Eng., in the production of steel barrels for the conveyance of petroleum. The barrels are made in halves by means of compression in a mold, when hot. Afterward they are welded together by means of electricity. The barrels are intended for use by the large oil carrying companies engaged in the oil trade in the East, where the temperature has a great effect on wood casks, and results in so much leakage.

THE CYCLOGRAM OF PRESSURES IN STEAM-ENGINES.*

By F. Edwards.

In multi-cylinder engines it is desirable to know what is the fall of pressure between an exhausting cylinder and the cylinder receiving the exhaust. It is also desirable to get at a glance an idea of the course of the steam, the time it is waiting in the receiver, and whether the steam from the bottom goes to the upper side or to the under side of the next piston. Whether the object of this inquiry be the better understanding of the action of the steam, or the determination of the validity of diagrams received as a set, the requisite comparison of simultaneous pressures cannot be read directly from indicator diagrams. At the Board of Trade office I have been shown the cyclogram or clock-face diagram, a very simple and very effective way of exhibiting this information. Not having seen this before, I think it will probably be new to most of our members, and that it may have a place in our *Transactions*, I have had the cyclogram now exhibited constructed. In the cyclogram the simultaneous pressures in all the cylinders are represented on the same radial line, to the same scale, and the differ-

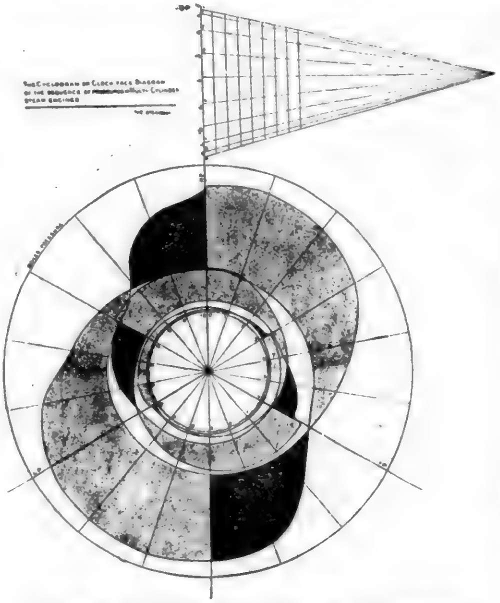


DIAGRAM ILLUSTRATING CYCLOGRAM OF PRESSURES.

ences and the sequence of pressures are therefore directly readable. To make such a diagram correct, including the obliquity of the connecting-rods, seems at first sight to be a somewhat complicated and troublesome problem, but it is really extremely simple, and its construction occupies very little time. For example, let the engine be a triple with the cranks at 120°. Describe a circle, say 6 in. diameter, draw a vertical center line, and, starting from it, divide the circle into 18 equal parts by radial lines. Number these from the center line 0 to 18. The number of divisions must be an even number, and one of them must coincide with the position of each crank. With the proportionate length of connecting-rod set off the corresponding crosshead positions on the center line, and number these, down one side and up the other, 0 to 18. Draw a horizontal line through No. 4, and from a point in it draw straight lines to the other cross-head positions. Draw a few vertical lines across these at, say, half an inch apart. Take now the indicator diagrams, which ought to be without ordinates, and mark the extreme lengths on the atmospheric lines. Fold each card along its atmospheric line with the diagram outward. Lay the folded high-pressure card parallel to the vertical lines, and with its ends on the extreme converging lines. The parallels are a guide to the eye in placing the card. Mark the divisions on the card with a fine pencil. Open the card and draw ordinates through these divisions and number them as on the center line. Do the same with the other cards, but observe to number the divisions on the intermediate from 6 and on the low from 12. Let the 6 in. circle denote the line of atmospheric pressure. Set off from this atmospheric circle on the radial lines the pressures found on the cards at the respective ordinates. The pressures are converted to the same scale by the usual method of inclined lines. Join the points thus obtained, and, where there is a change of curvature between two of the positions, be guided by the form of the card. Having ascertained the points at which the exhaust begins and ends, indicate, by short radial lines inward, the duration of exhaust, and by short radial lines outward the duration of steam admission into the succeeding cylinder. Shade the effective pressure areas. Show the compression area by dark shading. When a diagram has been obtained from the receiver, its ordinates must be numbered according to the crank whose motion actuated the indicator barrel when the diagram was taken. A little consideration will show that the crank must be placed on the diagram in the reverse order of the action of the steam. For example, this cyclogram is for the high leading, but the low crank is placed as if it were leading. This is, however, correct, and a little reflection will show you that it must be so, and any verbal explanations would only be likely to make this more difficult to grasp.

* Paper read before the Institution of Naval Architects.

PROGRESS OF TRANSATLANTIC NAVIGATION.

The *Revue Scientifique* gives the following *résumé* of the progress in transatlantic navigation from 1816 to the present day. Regular transatlantic navigation, which was brought to life in this century, has made a steady advance, the principal stages of which are given by the following figures:

The first regular line, the Black Ball, was inaugurated between New York and Liverpool in 1816. At that time the outward trip to New York occupied 23 days, and the return trip 40.

In 1836 the Dramatic Line launched the ship *New York*, of 1,400 tons displacement, which was at that time the largest ship in the world. At this time the sailing vessels were undergoing a process of very rapid improvement, and 14 years later, or in 1850, the passage could be made in 15 days under favorable conditions.

Then steam navigation was established. The first attempt had been made in 1819 with the *Savannah*, which was practically a sailing vessel equipped with an auxiliary engine, and which occupied 25 days in making the passage between Savannah and Liverpool, and in consequence of this attempt the English declared, previously and afterward, that it would be impossible to make a passage of the Atlantic Ocean by the assistance of steam alone.

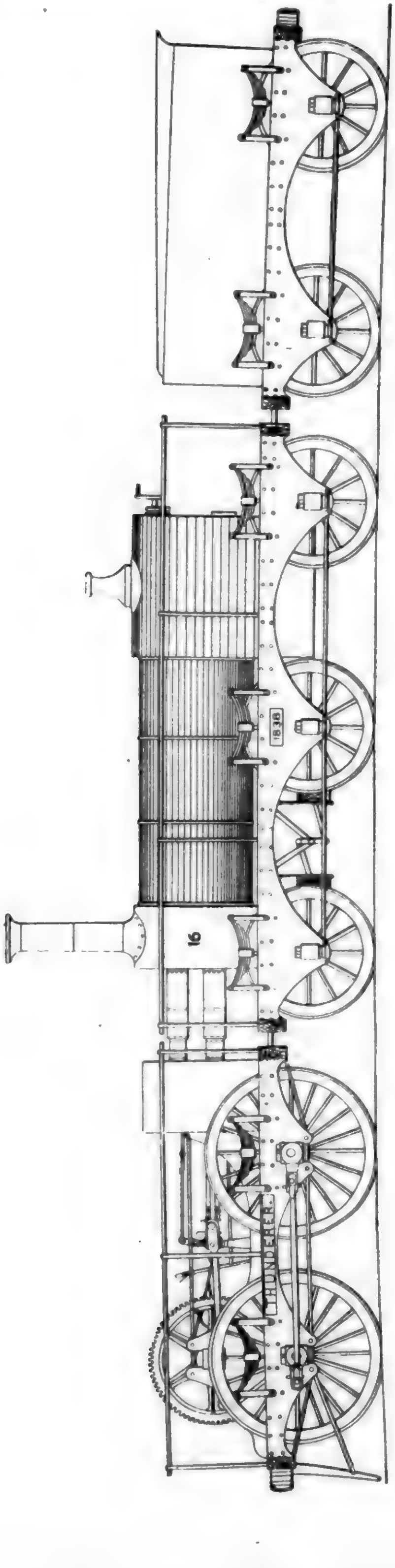
In 1838 the first steamer, the *Great Western*, was launched. She had a length of 213 ft. 3 in., a breadth of beam of 32 ft. 9.7 in., drew 16 ft. 4.8 in. of water and had a net displacement of 1,340 tons. She was equipped with a 440-H.P. engine. The first passage occupied 16 days, during which time from 27 to 32 tons of coal were burned every 24 hours. The return trip was accomplished in 14 days; and even in 1842 the record stood at 12 days, 7½ hours, which corresponds to a speed of about 8¼ miles per hour. A great step in advance was made when the *Great Britain* was built, with a length of 275 ft. 7.2 in., an iron hull, a screw propeller and an engine of 1,000 H.P.

As for the *Great Eastern*, that giant among ships, which measured 690 ft. in length, having a breadth of beam of 82 ft. and a depth of hold of 55 ft. 9 in., with a net tonnage of 18,915 and engines of 2,600 H.P., it was very evident that she had come before her time. She was furnished with accommodations for 4,000 passengers, without counting the 400 men constituting the crew. The steamer was, nevertheless, very well built, and obtained a speed of 14 miles per hour on her trial trip. But at that time there was no such throng of passengers traversing the Atlantic as there is to-day, and the traffic was insufficient to make her voyages paying investments; so that, after having been used for laying transatlantic cables, she was finally broken up in 1891.

In 1862 the French Compagnie Générale Transatlantique was organized, and from that time on the rivalry between the great lines has been on the constant increase.

In 1866 the *Pereire* was built, which crossed at the speed of 13¾ miles per hour, and was really a magnificent steamer of 6,000 tons burden. She was 374 ft. long, and equipped with an engine of 3,000 H.P.

In 1875 a new-comer, the White Star Line, had some ships 465 ft. long, with a beam of 46 ft., a depth of hold of 32 ft., and a speed of 14 knots.



LOCOMOTIVE "THUNDERER," WITH 6-FOOT DRIVING-WHEELS, BUILT IN 1838.

Since 1880 there has been a greater struggle than ever among the transatlantic lines to produce the largest and fastest steamer. In 1881 the Inman Line launched the *City of Rome*, which has a length of 544 ft., a beam of 55 ft., a depth of hold of 39 ft., a displacement of 8,400 tons, and a speed of 18 knots, which was made with an engine of 11,900 H.P.

In 1891 the Compagnie Transatlantique built the *Touraine* with a length of 515 ft., a beam of 55 ft., and an engine of 12,000 H.P., which gave them an average speed of 19 knots.

Finally, the latest comers are those of the Cunard Line, which has just launched two immense liners, the *Campania* and the *Lucania*, with a length of 597 ft., a beam of 65 ft., a depth of hold of 42 ft., a total tonnage of 12,500 and engines of from 14,000 H.P. to 15,000 H.P.

Regarded from the standpoint of the length of passage, the *City of Paris* at present holds the record, having made the trip from Queenstown to Sandy Hook in 5 days, 14 hours, and 24 minutes, which gives an average speed of 20.7 knots—a speed which has even reached that of 21.4 knots for a single day, or practically about 24.855 miles per hour.

LOCOMOTIVES "HURRICANE" AND "THUNDERER."

In our issue of February last we gave an engraving of the locomotive *Hurricane*, with driving-wheels 10 ft. in diameter, the largest which have ever been used. In the description which was given of this engine it was stated that, "as originally built, it had drivers 5 ft. in diameter, and the cylinders were coupled to an independent crank-shaft carrying a large pinion which geared into another on the driving-axle."

Mr. Clement E. Stretton, of Leicester, England, has written to us to correct this statement, and says:

"With regard to the *Hurricane*, the illustration on your p. 80 shows that engine as it was when built. *It was never altered;* but proving a failure was broken up. The engine illustrated in Wood's book of 1838, having four coupled wheels of 6 ft. diameter, is not the *Hurricane*, but the *Thunderer* of 1838. The *Thunderer* had 6 ft. wheels geared up three to one, so as to equal 18 ft.

"To make this quite clear to your readers, I beg to send by this post a blue print of the *Thunderer*.

"Clement E. Stretton."

The engraving herewith has been made from the blue print received from Mr. Stretton. His statements are confirmed, too, on a further examination of Wood's book. In his sixth chapter, p. 352, he says that "the Messrs. Hawthorn are now constructing an engine for that railroad (the Great Western), with driving wheels 10 ft. in diameter, calculated for a speed of 40 miles an hour."

In a later chapter, which was evidently written after Chapter VI., Mr. Wood says:

"With wheels of 10 ft. in diameter, the velocity of the piston is reduced nearly to the proper standard; but wheels of so large a diameter are very cumbrous and heavy, and produce a very considerable strain upon the axles.

"Mr. T. E. Harrison, Engineer to the Stanhope & Tyne Railway, has obtained a patent for an engine to obviate these inconveniences and objections, the driving-wheels of which make three revolutions for one entire stroke of the piston; and these wheels being 5 ft. in diameter, they are equivalent in speed to one wheel 15 ft. in diameter."

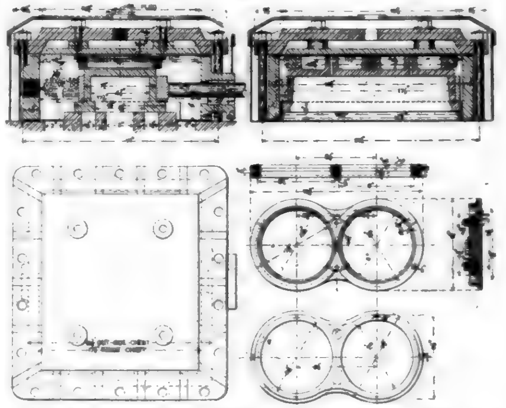
Quite an elaborate engraving is given of the engine showing a longitudinal section of the front or driving part of the machine, and its connections with the vehicle which carries the boiler. Measured on the scale given with the drawing, the driving-wheels measure 6 ft. 2 in. in diameter. Quite a full description, apparently taken from Harrison's patent, is given of the construction of this machine. At the end of the description Wood says: "One of these engines, constructed as shown in the drawing, and another without cog-wheels, and with the driving-wheel, *W*, 10 ft. in diameter, have been furnished by Messrs. R. & W. Hawthorn, of Newcastle, for the Great Western Railway."

THE LUBRICATION OF MARINE ENGINES.

At a recent meeting of the Institute of Marine Engineers, Mr. W. M. Ross presented a paper on the Lubrication of Marine Engines, of which we present a brief abstract:

The references in this paper were solely to vertical marine engines. No doubt they could be applied to other machinery as well, but the greatest number of marine engines of the pres-

ent day are of the vertical type. Lubrication might be divided into two classes—external and internal. Let them first consider the external. One of the principal parts of a marine engine was the crank-shaft and its various bearings, to which too much attention could never be given. In boring out bearings for a crank-shaft the general rule was to give a greater diameter than the shaft which had to revolve in them, a difference which might vary with the engineers, but in all cases the hardest points to come into action were the top and bottom centers and a gradual enlargement toward the sides. In the present method of supplying lubrication to these bearings, all oil holes were bored through the top center, and to enable the bearing to receive sufficient oil to overcome friction the outlets had to be greatly enlarged, and oil channels cut all over the bearing surface. This he considered wrong, and one of the greatest defects in anti-friction that could occur in any bearing in which the shaft had a revolving motion, as the sides of the bearings (and by that he meant any part away from the top and bottom centers) must have the greatest division of the two metals—in other words, less friction. Therefore the outlets should be distributed into that space, so that the shaft in revolving would carry its lubrication with it, drawing its supply as from a reservoir—inducing a better flow down the oil pipe instead of retarding it, as must take place when the pipes led directly to the top center of the bearings. Were it not for the enlargement of the oil tubes and the channels cut over the sur face, no lubrication would take place in these bearings at all. Nearly all main bearings were now fitted with white metal, or some other less tenacious metal than the brass itself, and were generally fitted in the outer brass or cast iron, as the case might be, in strips of about 4 in. in width, having one division on the top center into which the oil holes were led. This method had its advantages, but he thought that if this white metal were to be divided into three surfaces—that is, with two intermediate divisions only—they would give the bearings a better opportunity to distribute its work through all the component parts. They required only a bearing surface equal to the diameter of the shaft to insure a correct bearing, and, instead of the arrangements of the present day, they would get the oil supplied into the space on either side, and the whole metal be left as bearing surface on the bottom and top centers, the principal points of these bearings. He considered that all bearings in which the working part had a revolving motion should be supplied with lubrication not on the top center, but at some point away from that center. Then each side of the bearing would always have a better supply, and as a result they would have less friction, and consequently greater power. With regard to the lubrication of the crank-pin, the same defect was here seen as in the main bearings, and if it was wrong in one case, here it must show with greater force. The principal defect in crank-pin lubrication was, he thought, in the method of supply from the boxes, as at present fixed in most marine engines. The method of to-day, although without a doubt a great improvement upon the old style, fell, he thought, far short of perfection. Let them trace the connections. Generally they had a box fixed high up on the cylinder lagging, with pipes leading to another cup fixed on each side of the connecting-rod jaw; from these cups led other pipes (usually one from each) to another cup, fastened to the center of the connecting-rod, or at such a distance as to give clearance from the bottom corner of the guide, and to be handy for any oil to be given as the rod is working. From this cup ran three pipes, one to each side and one to the center. Now, from this last cup ran three outlet pipes, but it had only two supplies, and these two, in five sets of engines out of six, led directly over the side outlets; the center pipe got its supply only by chance. He considered that every outlet should have its own special supply. From the first box there should be sufficient oil supplied to guarantee each of the pipes leading into the brass getting its own proper amount regularly, and on no account should this most important bearing be left to chance lubrication, as in some cases at present. With engines running at the high speed of to-day, and with the long connecting-rods now in use, it was impossible for this pin to be oiled except automatically, let the greaser be ever so good; still there must be a great percentage lost when oil had to be supplied in this offhand manner. How many crank-pin bearings to day could be run without using the water service, which, although at times a blessing, when considered relatively to the life of the shaft and bearings was far otherwise. Many an anxious watch was passed and many a gallon of oil was wasted through this defective supply to a bearing. He hoped he had sufficiently shown the defect to justify a remedy as follows: Place the outlet holes not on the top center, but somewhere on the sides; give each hole an independent supply pipe, and, if the engine is properly balanced, there will be a much better working pin, and with better working we have less friction, and consequently longer life to both pin and bearings. After referring to tunnel-shaft bearings, and especially to what he considered the great room for improvement in the lubrication of the thrust block bearing, Mr. Ross said that the defects he had pointed out were common; and in the marine engine of to-day, brought up as it was to great perfection in design, lubrication should not be looked over or slighted. Regularity was one of its chief features; and let the "greaser" be ever so careful and competent, there must at times be periods in his watch, either through rough weather or extra attention required at some particular part, when this regularity could not be carried out; consequently bad lubrication took place. Every bearing throughout the engine should be supplied automatically and regularly, and if it could be carried out in small engines (as was now being greatly done), how much easier could it be arranged with the large machines of to-day. Perhaps at this point a few words might not be out of place in regard to the rule in a good many steamers (not liners, but in what were called outsiders or tramps) of the engineers having to oil the machinery unaided. In these times, when they were trying to elevate themselves and those who were to follow them, and to bring a more scientific training into every-day use, it seemed very wrong that trained engineers should be turned into oil feeders. No engineer in charge of a watch could properly devote his attention to all in his charge, be it ever so small, if his time had to be given up to oiling; something must be neglected. Without doubt there had been a great improvement in recent years in internal lubrication. The old pot impermeator had been entirely superseded by the automatic sight-feed—an arrangement in all its workings simple and effective. With the old style, oil was



BALANCED SLIDE-VALVE, DELAWARE & HUDSON CANAL CO.

generally put in twice a day; if it worked, well and good; but generally it did not. Now, every drop told a tale, and gave the satisfaction with the knowledge that all was going well. In the present day, with steam of very high temperature, little or perhaps no internal lubrication was necessary. Many engineers had entirely discarded the supply through the impermeator. But with this he did not agree. Granted that the high-pressure steam required no oil, when this steam reached the low-pressure engine the temperature had decreased greatly, and here it was where he always found the most mischief took place. With the large working area of the low-pressure piston, some lubrication, he considered, was necessary; very little sufficed, but still some was required. If the impermeator, instead of supplying the oil to the steam at its first initial pressure, were so placed that the supply could be given at the time the steam entered the low-pressure valve chest, he really thought more good would be done, as the lubricating properties of the oil would not be destroyed through coming in contact with steam of high temperature, but would pass at once into the parts requiring it most. With internal lubrication, they must not overlook that taken in with the piston-rods, an amount, he was afraid, greatly overlooked by most engineers in their calculations. Although oil given to these rods could not be absorbed by the steam, still he considered at least 20 per cent. was used for that purpose; and on no consideration should any but mineral oils be used. With engines having top end rods automatic supply was very easy, and the bottom rods could be as easily supplied as the top, and from his own personal experience good results had been obtained, not only in the life of the packing, but in the wear of the rods

themselves. With a pair of engines of 2,500 H.P., he found that the piston-rods (with top ends oiled automatically), and three valve spindles, required one pint per watch of four hours' duration—*i.e.*, six pints in 24 hours. Now, if, as he maintained, a fair percentage was absorbed by the steam while the rods were internally working, they had one to two pints used from this source alone for internal lubrication, and the impermeator, being fixed to the low-pressure valve chest, would use .8 pint. They had, therefore, used two pints in the 24 hours. Not a very large amount, and he did not think it could be very much reduced. In closing, Mr. Ross said he would call friction the strongest enemy in a marine engine, and if lubrication was the best way to overcome it, the most perfect method should be adopted. The following points had been present to his mind while writing: 1. All revolving shafts should be supplied with lubrication, not through the vertical center, but somewhere at the sides. 2. Every supply outlet to the crank-pin should have its own separate supply inlet from the commencement to the finish. 3. Each and every bearing, whether small or great, should be supplied automatically; there should be no chance lubrication in connection with a marine engine of to-day. 4. No internal lubrication should be used, excepting through the impermeator affixed to low-pressure engine, and lubricating or swabbing piston-rods and valve-rods, with mineral oils alone. 5. Greater thought and more care should be given by designers and builders to the lubricating arrangements, and less to the superfluous water service, as at present. 6. No marine engineer of modern training should be asked to act as the oil feeder of the watch; he has more important duties to attend to.

facture and to maintain. Of course they do not obtain the same area of balanced portion of the valve that is obtained when the packing comes out square and full with the whole upper surface, but sufficient balancing is obtained so that the valve runs very easily and the saving in the manufacture is considered to more than compensate for the extra loss of power required in driving the valve.

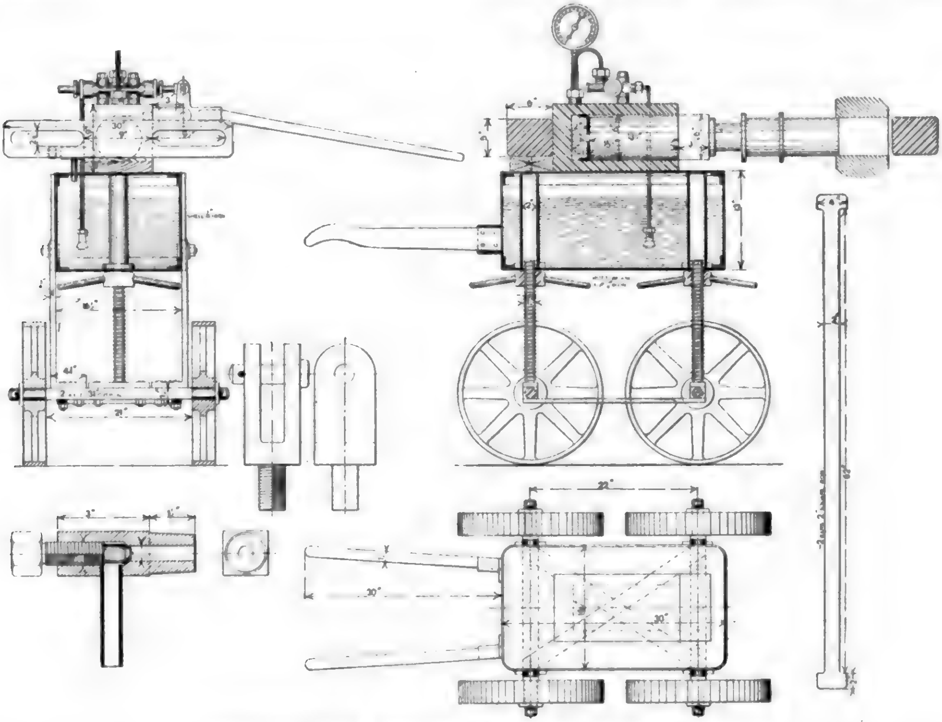
The steam-chest is of the same shape as that ordinarily used, and the cover has the balance plate cast separate from it and is held to it by bolts as shown in the top of the engraving. The plan shows the method of making the packing rings, which consist of two circles brought as near together as possible with the ordinary form of packing rings slipping down over a circular section and provided with the spiral springs for holding them down in position as is shown.

CRANK-PIN PRESS.

This press is a very convenient portable machine, which is used about the shops for removing and putting in crank-pins while the drivers are still under the engine.

Its construction and general dimensions are very clearly shown by the engravings. It will be seen from an examination that the press is mounted on a four-wheeled truck, and that the tank and body of the press itself are carried on screws by which it can be elevated or depressed so that the center line of the ram will come in line with the center of the crank-pin when the press is to be used.

The bars shown at the right of the engraving are used to lock into the spokes of the driving-wheel, and also into the tail-bar back of the press. The pressure can then be applied



CRANK-PIN PRESS, DELAWARE & HUDSON CANAL COMPANY.

SPECIAL TOOLS OF THE DELAWARE & HUDSON CANAL COMPANY'S RAILROAD.

BALANCED SLIDE VALVE.

The balanced slide valve of which we give a full detailed illustration is in general use upon the locomotives of the road, and is being applied to all engines as they come into the shop for repairs if they have not been equipped with it before. The principal feature wherein this balanced valve differs from those in ordinary use is that the balancing backing at the top is round instead of square, which makes it far cheaper to manu-

and the pin forced in as shown in the side elevation and section of the press. The ram is 6 in. in diameter, and the cylinder will sustain a pressure sufficient to put in any pin that may be desired.

The pumping arrangement is very simple, and is located on top of the ram with a bell crank attachment for operating the plunger and for connecting a lever which is 36 in. long and made by $1\frac{1}{4} \times \frac{1}{2}$ in. iron. When the press is in use, although it is carried on top of the tank, no strain is put upon the latter except merely that of carrying the dead weight of the ram.

The wheels are of cast iron and run loose on the wrought-iron axles. The screws which are used for elevating and de-

pressing the plunger run in the sleeves in the interior of the tank, so that they are out of the way, and there is no necessity for any other provision being made for them. The general construction and operation of the press will be very readily understood from an examination of the engravings.

HYDRAULIC LOCOMOTIVE LIFT.

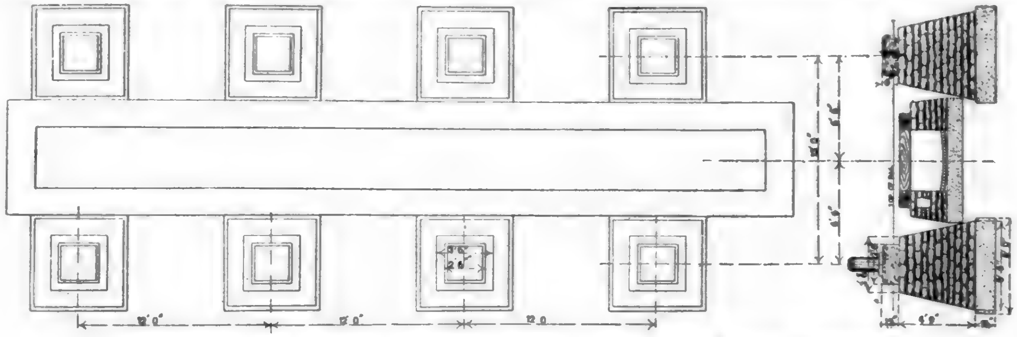
Probably two of the most valuable and useful special tools that are in use upon this road are the hydraulic locomotive lifts in the Green Island and Whitehall shops. As that used in the Green Island shops was the first one constructed, and as several improvements have been made in the one built later for the Whitehall shops, we limit our description and illustrations to the latter.

The general plan of the lift is that it consists of four inverted hydraulic cylinders so arranged that they can be shifted and brought into such a position that any locomotive on the road can be very readily and rapidly lifted from its wheels. The foundation plan shows that there is a pit with stone side walls beneath the track, and that on either side there are four columns of cast iron resting upon stone foundations located 12 ft. apart from center to center, with a central distance across the track of 13 ft. These columns rise to a height of 17 ft. 9½ in. and carry on their upper extremities two 15-in. I-beams, weighing 150 lbs. to the yard, and 38 ft. long. It is estimated that the safe load for these beams on the 12-ft. span between the columns is 11 tons.

Near one end, which is used for the back end of the locomotive, there are two 12-in cross I-beams, weighing 170 lbs. to the yard. These are riveted fast in position and carry two hydraulic cylinders 18 in. in diameter and 6 ft. long on the inside.

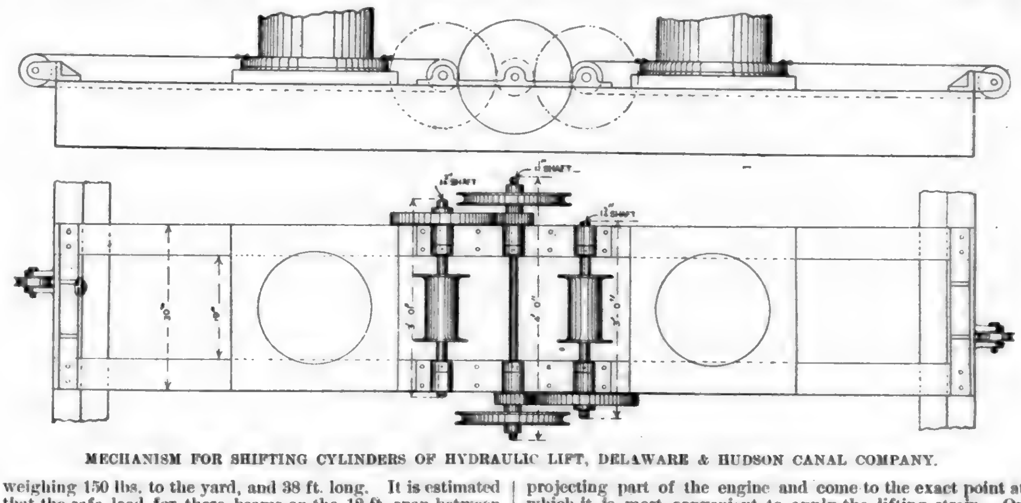
The general construction of the piston which is used is clearly shown by the detail engravings. It consists of a spider against which an ordinary leather packing with a spider back of it is placed; then against this second spider there is a second leather backing, the whole being drawn up into position by a follower plate 1 in. thick. As these cylinders are only called upon to operate in one direction, the packing is turned downward so that the second one tends to supplement the first and catch any leakage which may pass through it. These two back cylinders are spaced 10 ft. from center to center, which is far enough apart to have their piston-rods clear the extreme outer ends of the bumpers or tail bars of any locomotive on the road.

The piston-rods are held in the pistons by means of a nut over which a key is driven in order to prevent it from backing off. The thread where the nut screws on is 2¼ in. in diameter, while the piston-rod is 2¾ in. This rod is 6 ft. 11 in. long from the shoulder at the bottom of the piston to the center of the pin of the hangers. Two bars of 3 in. × ¾ in. iron are suspended from the piston-rod, and they in turn are fitted at the lower extremities, as shown by the engraving, with keyholes upon which a cross bar of 10 in. × 2 in. iron is laid, which acts as a direct lifting bar on which the locomotive to be raised rests.



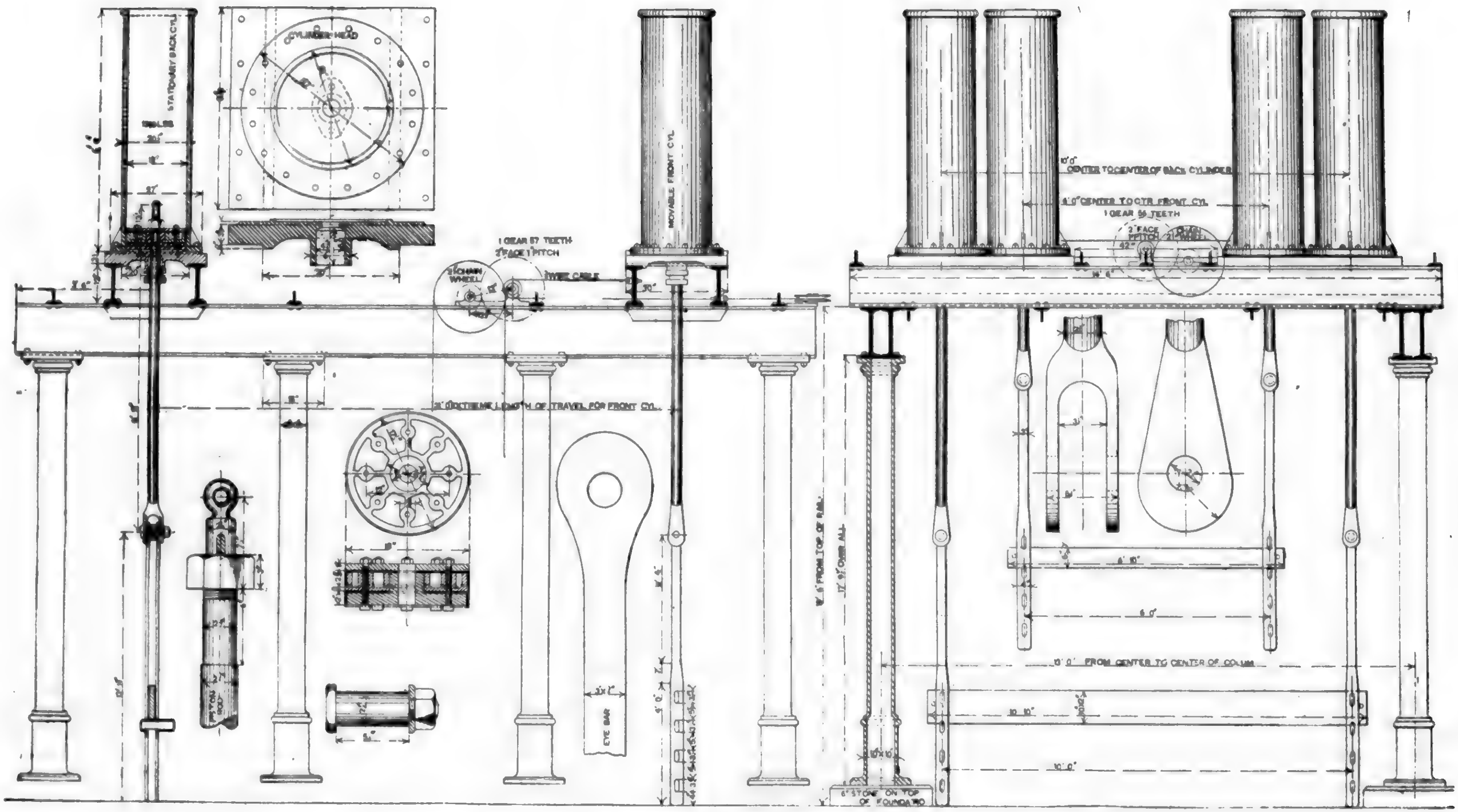
FOUNDATION FOR HYDRAULIC LOCOMOTIVE LIFT, DELAWARE & HUDSON CANAL COMPANY.

At the front end there are two cylinders of the same size as those at the back, but they are movable both across the frame and lengthwise with it. This is in order to enable the workmen to adjust the suspension rods so that they will clear any projecting part of the engine and come to the exact point at which it is most convenient to apply the lifting strain. On ordinary locomotives they must be adjusted so as to come just ahead of the cylinder and back of the front buffer beam. The piston-rods are of the same size as those at the back and the suspension rods the same; the principal difference between them being that the cross bar which goes beneath the engine is of 6 in. × 1½ in. iron instead of 10 in. × 2 in.



MECHANISM FOR SHIFTING CYLINDERS OF HYDRAULIC LIFT, DELAWARE & HUDSON CANAL COMPANY.

These movable cylinders rest on cast-iron bed pieces which are arranged so as to slide back and forth on the cross channel beams supporting them, and these channel beams are themselves made so that they slide longitudinally on the 15-in.



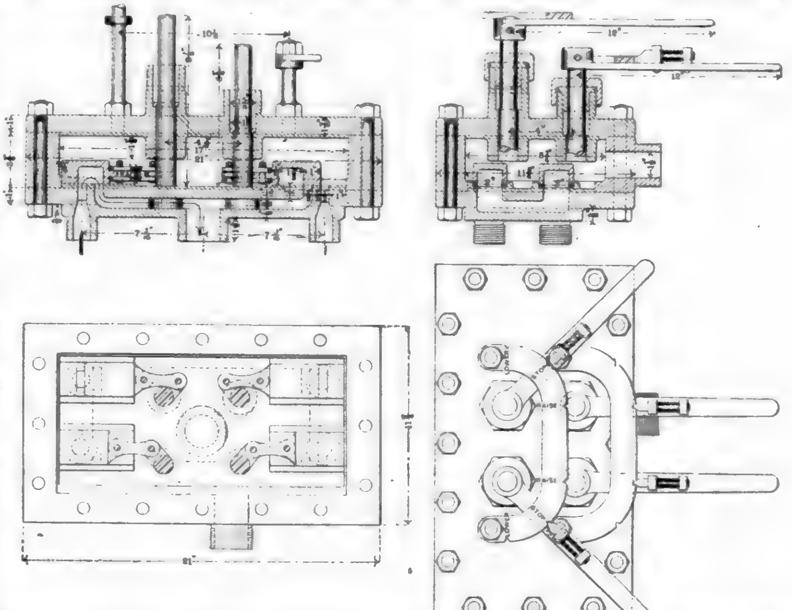
HYDRAULIC LOCOMOTIVE LIFT, WHITEHALL SHOPS, DELAWARE & HUDSON CANAL COMPANY.

beams that rest on top of the columns, the latter being planed off so that there is a smooth bearing surface for the cross-beams. The mechanism which is used for shifting both the cylinders and the I-beams is a very simple construction. It consists merely of a couple of spools with geared shaft so arranged as to wind up on one and slacken off on the other, with a wire rope running around an idle sheave at the extreme front end of the lift. The arrangement used for moving the cylinders is shown by the detailed drawing. Here the two spools are in line with one another, each one operating a cylinder.

It will be seen that the rope starts from one cylinder, passes over the drum and beneath the cylinder over the idler below, and takes hold of the base of the cylinder on the opposite side from that on which it starts, so that by reversing the motion of the drum the cylinders are drawn toward the center or outside of the frames by exactly the same amount, thus maintaining them at equal distances at either side of the center line. The rapidity with which locomotives can be raised and the driving-wheels removed with this apparatus is very great. On one occasion in the Green Island shops, where the lift is not considered to be rapid in its motion, or as effective as that illustrated, a locomotive was lifted from the driving-wheels, the wheels rolled out, and the engine put back on its blocking in 2½ minutes.

The capacity of each cylinder with a 5-ft. stroke is 65.34 galls. Working under 95 lbs. natural pressure and a ½-in. nozzle, it requires 6 minutes to fill the four cylinders. By using a double 3 in. × 6 in. force pump the four cylinders can be filled in 9 minutes, or 120 revolutions.

The total weight of the cast iron used in the machine is 17,912 lbs., and wrought iron 14,709 lbs. The valve arrangement for manipulating the hoist is a very simple construction, and is shown by a special engraving. Water is taken under pressure of about 80 lbs. and admitted to a box with a cover $1\frac{3}{16}$ in. thick. From the bottom of this box there are five pipes, four of which lead, one to the bottom of each of the four cylinders respectively, entering beneath the lowest position of the piston. The fifth is an exhaust and leads to a sewer or other discharge.



OPERATING VALVE FOR HYDRAULIC LOCOMOTIVE LIFT. DELAWARE & HUDSON CANAL COMPANY.

There are four handles, as shown by the plan view, and the whole is placed in a pit just back of the pit beneath the lift. Each one of these handles controls a slide valve which covers the opening into the pipes leading to the cylinders. When it is desired to raise, the handle is simply pushed so that the catch drops into the notch marked "Raise;" water under pressure is then admitted from the main into the bottom of the cylinder corresponding to the handle manipulated. When a sufficient height has been reached, the handle is moved to the "Stop" position at which the slide valve covers the opening and holds the water in the pipe and cylinder, thus preventing the piston from descending. When moved further to the "Lower" position, the water flows back through the same pipe and out of the *D* of the valve into the exhaust. The amount can be regulated so that the engine can be lowered with any speed desired.

It is well known as one of the difficulties where engines are hoisted by jacks or other rigid means, that when it is desired to replace the wheels, generally the engine is a little out of the center line of the track, and that almost invariably the wheels will be crowding one rail or the other, so that it requires a deal of pinching and crowding in order to move the engine until it stands central with the wheels upon which it is to be placed. With this lift, however, the engine can be swung like a child in an ordinary swing, and one man can very readily adjust it so that the pedestals will drop down over the driving-boxes at once and without any undue exertion.

GERMAN CORRIDOR TRAINS.

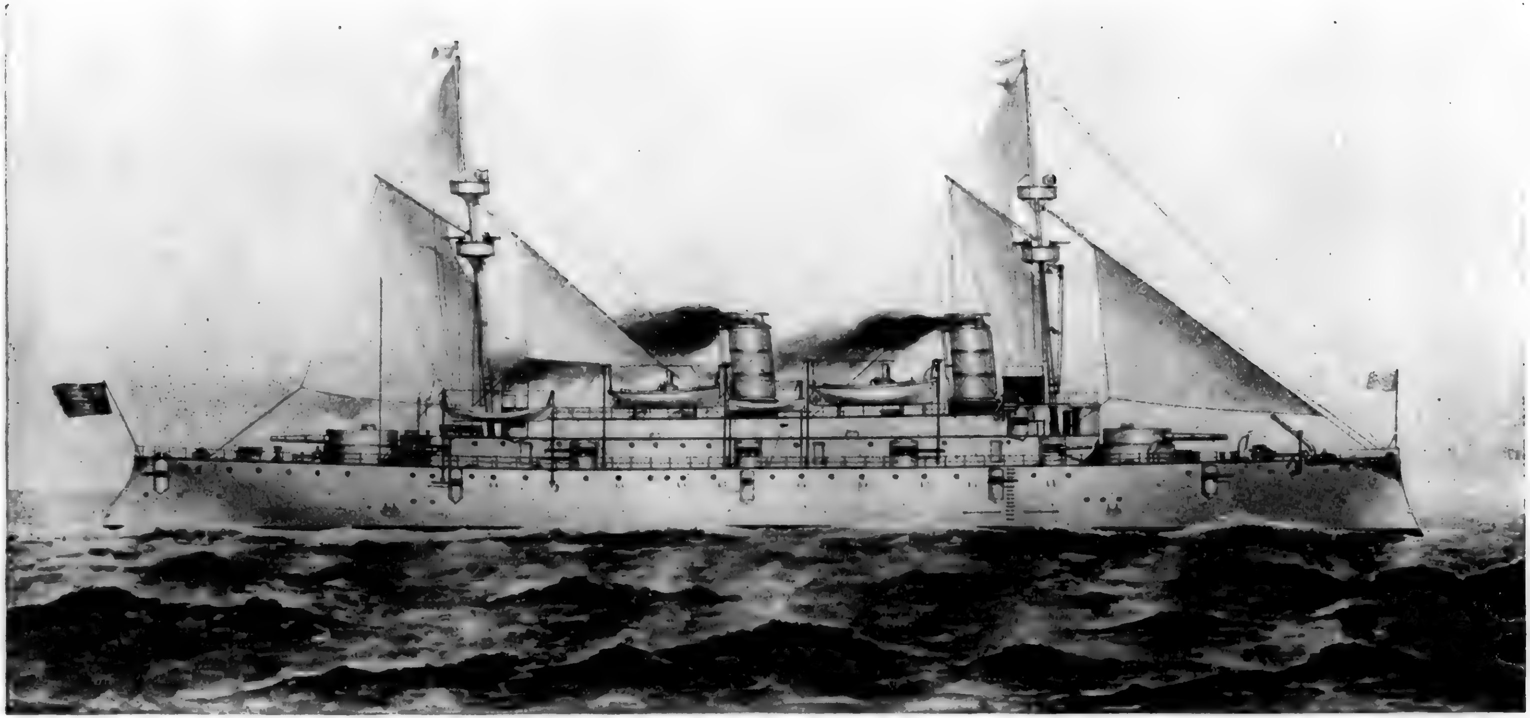
THE success which has attended the introduction of corridor trains on various European railways has induced the administration of Prussian railways to order a number of them for their express traffic. Since May 1st, twenty-four such trains have been running on the lines worked by the Prussian State, more especially between Berlin and Cologne, and Berlin and Frankfort-on-the-Main. It may be remarked that corridor carriages are of German origin, having been first designed by the late Heusinger von Waldegg; the principle was applied, however, only to four and six-wheel carriages, which were provided with lavatories at one or both ends. Since 1875 this design has received numerous applications, and new stock for foreign railways is built according to it, in preference to the older system with central passage.

The twenty-four trains of which we are going to give a description embody all the features of the modern American rolling stock. Each train consists of five bogie carriages, which have the same external appearance as those owned by the International Sleeping Car Company; the bogies are four-wheeled and of the usual pattern. Thorough communication from one end of the train to the other is established by means of small bridges uniting the end platforms of the cars, and in order to afford better protection against accidents to passengers going from one car to another, each bridge is completely covered by a leather awning, as is done in England to connect mail vans. These cars are 52 ft. 11 in. long, and each one of them is provided with two lavatories.

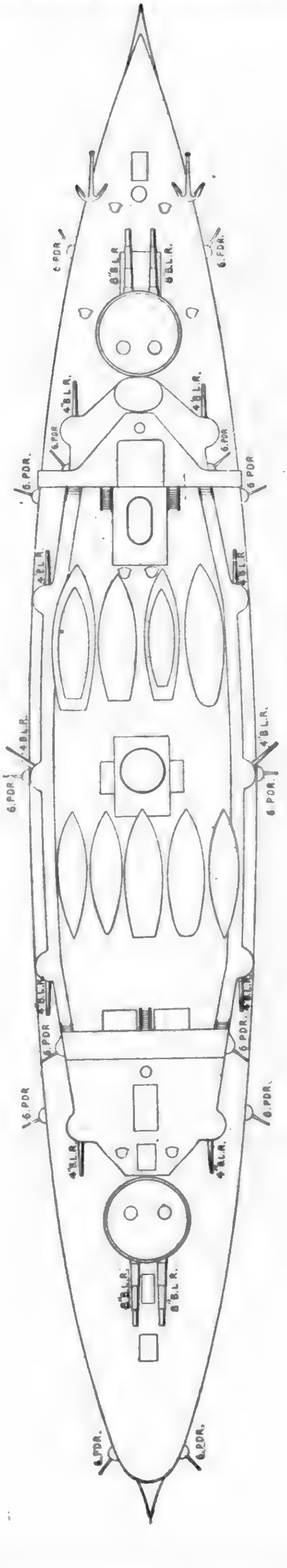
The Westinghouse brake has been fitted on all these trains. The lighting is effected by means of regenerative gas lamps. The last car but one contains a restaurant and kitchen, where cooking is done by gas. The catering of these dining cars will be leased to private refreshment contractors. Communication between this car and the others is effected by electric bells. One guard and train conductor will be the only railway servants attached to the train; the first will travel in the luggage van and the second in the anteroom of the last car.

The trains contain 126 seats each; 24 to 30 are first and the remainder all second-class. Each car contains seats so constructed that when not occupied they stand vertically, and are kept automatically against the sides of the car. This arrangement is generally met with in all German corridor carriages of more or less recent construction. As usual, special compartments are set apart for non-smokers and ladies traveling alone.

All places are numbered, and particular seats can be secured in advance on payment of an extra charge of one mark; but these must be applied for at the booking office at least half an



UNITED STATES PROTECTED CRUISER "OLYMPIA," BUILT BY THE UNION IRON WORKS, SAN FRANCISCO, CAL.



UNITED STATES PROTECTED CRUISER "OLYMPIA." DECK PLAN.

hour before the departure of the train. When a seat has thus been engaged a special notice is attached to it showing that it is reserved.

Some of the ordinary express trains, with the usual first and second-class, will continue to run as in the past; but if we understand it right, on some lines passengers wishing to travel by these new *trains de luxe* will be charged a supplemental fare of two shillings. This extra fare may be paid at the booking office or to the train conductor.

The maximum dimensions adopted by the Union of German Railway Administrations for the construction of cars being of a more liberal nature than those which obtain in England, German engineers will have no difficulty in providing comfortable and roomy corridor cars in which the proportion of paying to dead load will be no greater, if not actually less, than it is in the four or six-wheel stock of the antiquated English pattern with rigid wheel bases.—*The Railway Herald.*

U. S. PROTECTED CRUISER "OLYMPIA."

This man-of-war represents the first high-speed vessel of the protected cruiser type designed for the new Navy of the United States to meet the conditions imposed by the rapid development of quick-firing guns and shell filled with high explosives.

Features hitherto unattained in this type have been introduced in the protection given to the battery and stability of the vessel. Experiment has established the fact that shells of small size filled with melanite, cordite, or like substances, when exploded near the side of the vessel in the vicinity of the load-line, have the effect of tearing away large portions of the thin plating which forms the sides of all unarmored cruisers, thus leaving the portions of the vessel above the protective deck open to the water, the protective deck itself being of sufficient thickness to preclude any possibility of damage to the vitals of the ship, which are placed beneath it, from the fragments of small shell; but with the admission of water to the portions above this deck the stability of the vessel is lost, therefore some means, where the use of armor plating is not admissible, must be adopted to keep out the water and thus maintain the stability.

To accomplish this the usual practice has been to divide the compartments above the protective deck into a large number of cells, making it necessary to fill a number of them before the seaworthiness of the ship is affected to a serious extent. In this vessel, however, the security resulting from cellular construction has been augmented by working an enclosed belt of water-excluding material 3 ft. wide and 8 ft. deep around the entire vessel, the weight of the material being about one-sixth of that of a corresponding bulk of water. This has the effect of providing a double hull in the vicinity of the water-line for the full length of the ship. Inside of this belt the cells in the wake of boilers and engines are filled with coal, thus reducing the possible admission of water to a minimum.

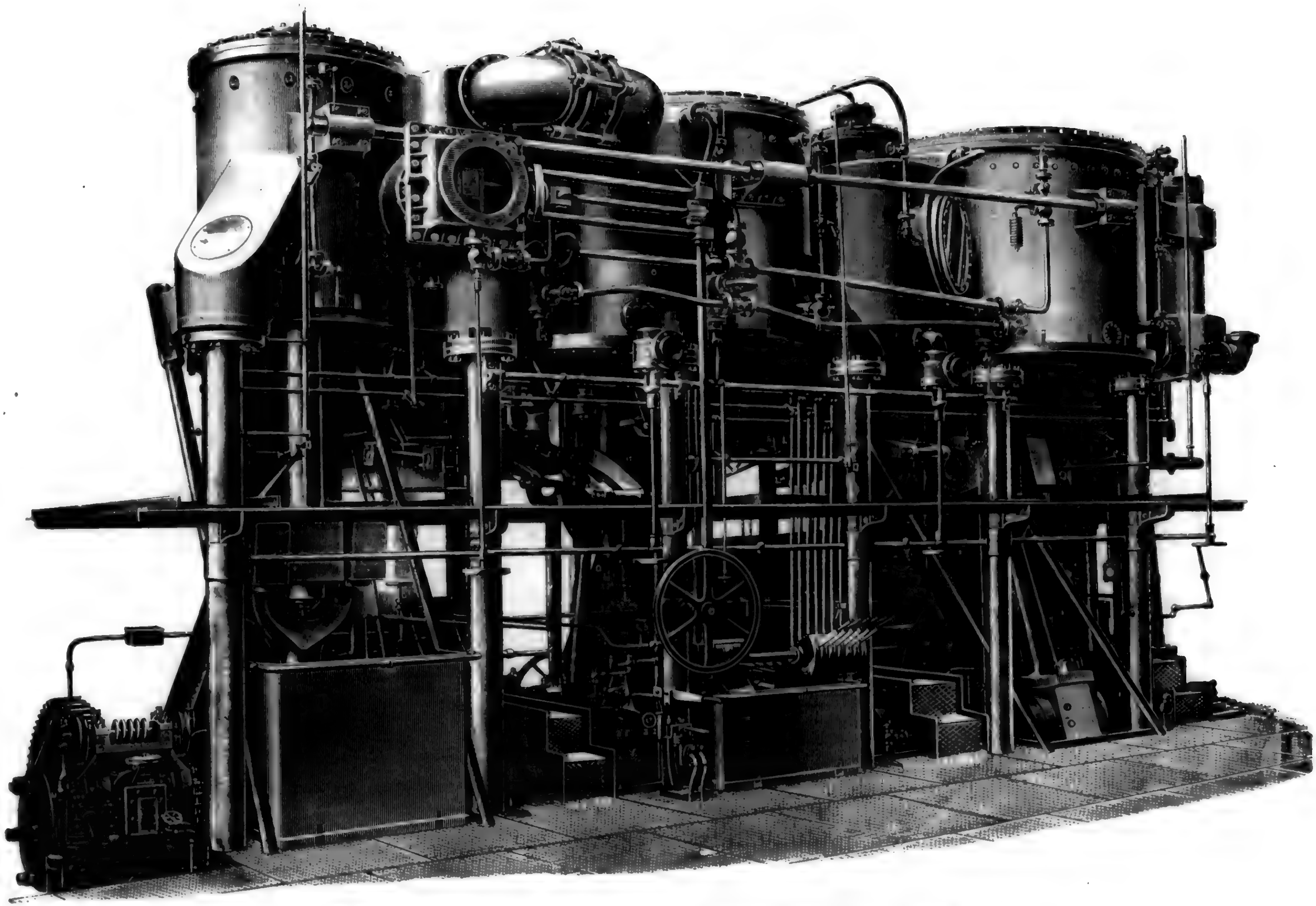
The protection given to the battery in unarmored cruisers is generally a light shield attached to the guns; but the 8-in. guns of the *Olympia* are mounted in barbette turrets protected by Harveyized armor plates 4 in. in thickness, while the 5-in. and other rapid-firing guns are protected by armor varying from 4 to 2 in. in thickness.

The hull is constructed on the longitudinal system, with double bottom extending over the space occupied by the magazines, boilers, and engines, throughout which the frames are spaced 4 ft. apart, giving an area of bottom plating unsupported of some 25 sq ft. in each frame space. Mild steel is used throughout as the material of construction, with the stem, sternpost and shaft struts of cast steel.

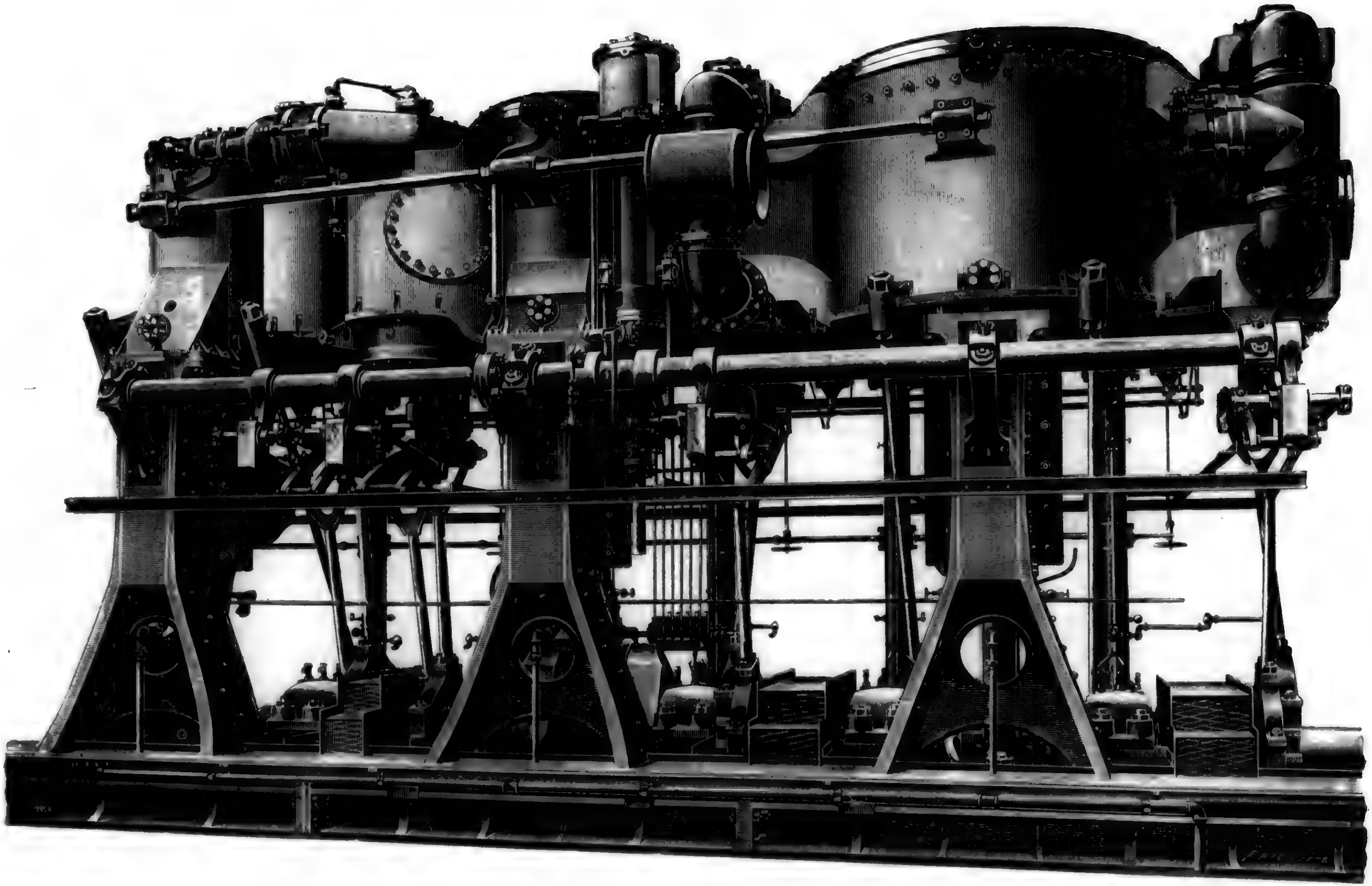
The protective deck, beneath which are placed the magazines, boilers and engines, reaches from end to end of the vessel. At the sides it is 5 ft. below the water-line, sloping upward and inward to 1 ft. above the same line. This deck is 4½ in. thick on the slopes and 3 in. on the flat over the machinery, being reduced to 3 in. over the entire surface at the ends.

The propelling machinery consists of two vertical, inverted, direct-acting triple-expansion engines driving twin screws; each engine is placed in a separate water-tight compartment, with the high-pressure cylinders forward. The cylinders are 42, 59 and 92 in. in diameter, with 42 in. stroke, and are capable, when making 129 revolutions per minute, of developing, with their auxiliaries, 13,500 H.P.; the main valves are of the piston type, driven by Stephenson links fitted with steam reversing gear and hydraulic controlling cylinders. The piston, crank-shafts and connecting-rods are of forged steel. The condenser shells are of rolled brass with cast-brass heads, and each condenser has 9,495 sq. ft. of cooling surface.

Condensing water is supplied to the condensers by two cir-



ENGINES OF THE UNITED STATES PROTECTED CRUISER "OLYMPIA." FRONT VIEW. (*From "Engineering."*)



ENGINES OF THE UNITED STATES PROTECTED CRUISER "OLYMPIA." REAR VIEW. (*From "Engineering."*)

culating pumps, each capable of discharging 6,750 galls. per minute, and are fitted so as to be able to draw from the main drainage system of the vessel at will. The boilers are six in number, each 15 ft. 3 in. outside diameter, four of them are double ended, 21 ft. 3 in. long, and two single ended, 10 ft. 11½ in. in length. The total heating surface is 28,298 sq. ft., with a grate surface of 824 sq. ft. The designed working pressure is 160 lbs. per square inch. The propellers are four bladed, with the blades bolted to the hub and provision made for altering the pitch.

The main battery is placed entirely upon the main deck, the 8-in. guns being mounted in pairs at the end of the superstructure in barbette turrets, with coned ammunition tubes leading to the protective deck. The 5-in guns are mounted within the superstructure, and so arranged that four can fire ahead and astern, and five on either broadside; these are protected by fixed segmental shields 4 in. in thickness. The auxiliary battery is placed above and below the main battery in positions that afford the greatest range and command possible, a noteworthy feature being the emplacement of the 6-pdr. guns on the deck below the main battery, so that a belt of fire may be maintained all about the vessel without any danger from the interference of the blast of the larger guns, the electric search lights being arranged to light up all portions of this belt.

Two masts are fitted each with military and search light tops, sufficient sail being carried to steady the vessel in a sea way. Most approved and modern plants for electric lighting, ventilation, and drainage have been provided.

The principal dimensions are as follows:

Length on load water-line.	340 ft.
Breadth molded.	53 "
Normal mean draft.	21½ "
Displacement, mean draft.	5,500 tons
Maximum I. H. P.	13,500
Guaranteed speed on trial.	20 knots
Sustained sea speed.	19 "
Main battery.	4 ft. 8 in. B. L. R. 10 ft. 5 in. R. F. B. L. R.
Secondary battery.	14 ft. 6 in. pdr. R. F. guns 6 ft. 1 in. pdr. R. F. guns 4 Gatlings 6 torpedo-tubes.

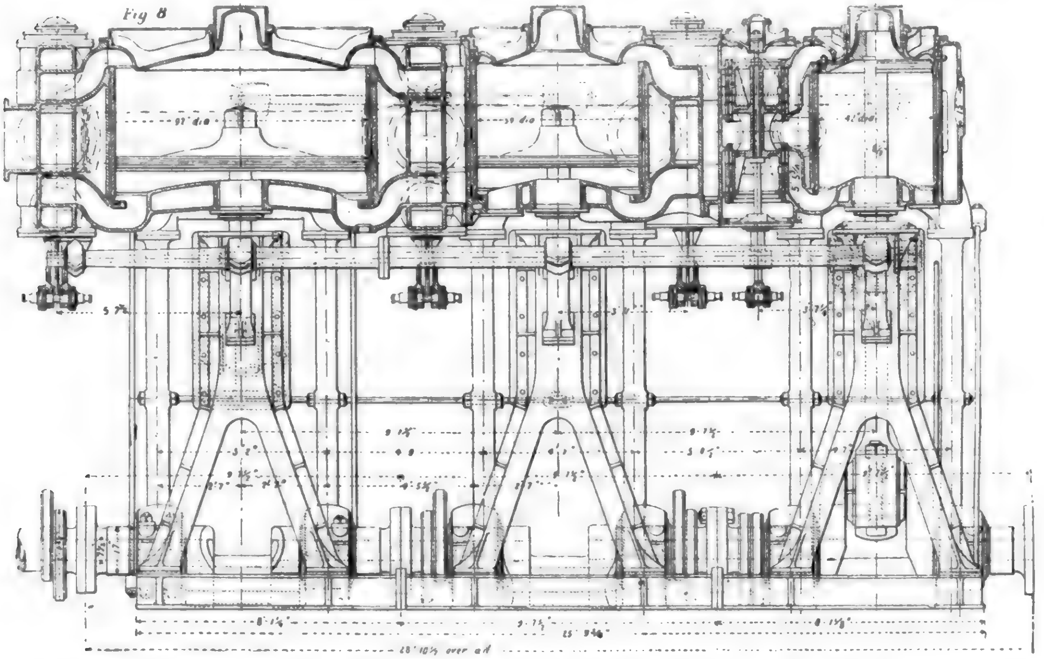
In addition to the regular armor there are also six torpedo-tubes. The maximum coal capacity put at 1,300 tons and the endurance of the vessel at 10 knots, with full coal supply is 13,000 miles.

It will be seen by an examination of the dimensions which have just been given that the *Olympia* exceeds in size any of her predecessors in the United States Navy. Referring once more to the engines, for the engravings of which we are indebted to *Engineering*, it will be seen that for each of the high-pressure cylinders there is one double-ported valve and two single-ported ones for each intermediate cylinder, and four single-ported for each low-pressure cylinder. The valves in the intermediate and low-pressure cylinders are packed in the usual manner with rings, but the high-pressure valve is not packed. The diameters of these valves are: high-pressure, 18 in.; intermediate, 23 in.; low-pressure, 21 in. The intermediate and low-pressure cylinders are steam packed, and the high-pressure cylinders are provided with liners, all the rubbing parts being made of cast iron. As originally designed, the framing was to have consisted of inverted Y frames at the back and cast steel cylindrical columns in the front, with cross bracing. In the longitudinal elevation of the engine and in the end view these columns are shown as castings as designed. Owing to the difficulty of obtaining these castings, it was determined to substitute built-up Y frames of wrought iron. These are shown in our engraving on the full-page plates, which, being taken from photographs of the engines, naturally presents the work as actually carried out. The cast-steel columns are also replaced in the design by columns of forged steel. The bed plate of I section, on which the columns are supported, is of manganese bronze instead of steel, as originally designed.

The crank-shafts are 16 in. in diameter, with an axial hole of 7½ in. The crank-pins are 17 in. in diameter, with 8½ in. axial holes. The crank shafts are in three sections, which are interchangeable and reversible.

The construction of the *Olympia* was authorized by act of Congress, approved September 7, 1888, to cost, exclusive of armaments and premiums, not more than $1,800,000. Bids were opened June 10, 1890, and the contract was awarded to the Union Iron Works of San Francisco, Cal., for the completion of the vessel by April 1, 1893.

The vessel is now nearing completion.



LONGITUDINAL SECTION OF ENGINES, UNITED STATES CRUISER "OLYMPIA." (*From "Engineering."*)

PROGRESS IN FLYING MACHINES.

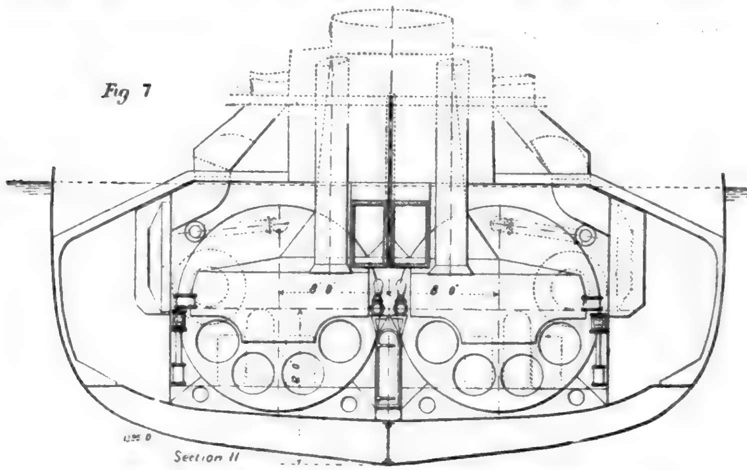
By O. Chanute, C.E.

(*Continued from page 295.*)

At the annual meeting of the American Association for the Advancement of Science, held in Buffalo, N. Y., in 1886, a paper on The Soaring Birds was read by Mr. *Lancaster*, then of Chicago, which paper attracted great interest and attention.

Mr. *Lancaster*, in the hope of surprising the secret of the birds, had the pluck, in 1876, to exile himself to the wilderness of Southwestern Florida, on the Gulf coast, near the Everglades, and there to remain for five consecutive years watching the sailing of the master soarers. He published some of his observations and deductions in the London *Engineer*, in the reports of the Aeronautical Society of Great Britain, and in the *American Naturalist;* but the subject was by no means exhausted, and his description of the phenomena observed was so interesting to the members of the association, few of whom had ever seen a soaring bird at close range, that they demanded to hear more upon a subsequent day.

Fig 7



UNITED STATES CRUISER "OLYMPIA." CROSS-SECTION AMIDSHIPS.

Unfortunately for Mr. *Lancaster*, upon the latter occasion he attempted to give a mechanical and mathematical explanation of the performances which he had previously so well described, and his theory was so plainly erroneous that he was subjected to harsh ridicule and criticism. He had witnessed some remarkable feats of "Aspiration," he had attempted to reproduce them artificially, but he was clearly wrong in his expounding of the mystery, and his critics did not properly discriminate between the statements of observed facts and the attempted explanation.

The principal issue, however, was made concerning some attempts to imitate soaring action, which Mr. *Lancaster* claimed to have successfully made in Florida, and which he unwisely declined to exhibit at Buffalo. He had described them in his paper as follows:

I constructed floating planes which, for lack of a better name, I have termed "effigies," and which are an example in point. I have made scores of them. They would draw into the breeze from the hand and simulate the soaring birds perfectly, moving on horizontal lines or on an inclination to a vertical. They would float in the best winds with neither ledge, rough front surface nor rear curve, if very nicely adjusted; but one of this construction I never induced to pass beyond the limits of vision, as the equilibrium was so very delicate that a little inequality in the wind current would capsize it.

There is every probability that such an experiment would invariably fail if tried in any but a perfectly steady sea breeze, an inflowing current of air with peculiar conditions; but it does not follow that the action described is impossible, for if we presume that current to have an upward trend (and the writer knows, of his own knowledge, that such upward trends are not rare in sea breezes), we can readily see that an aeroplane, tipped forward so as to point below the horizon, may be both sustained and "aspirated," or possess a forward component of pressure, so that it may advance against the wind, and rise, at the same time, like the kite of M. *Myers*.

The equilibrium is, of course, excessively delicate, and hence the requirement for a sea breeze: for a local homogeneous mass of air flowing from the water over the land to replace the rising quantity heated by the sun; but it is erroneous to suppose that the experiment described by Mr. *Lancaster* involves a mechanical impossibility. It is, doubtless, difficult to repeat it successfully, because it requires a combination of peculiar conditions; but the soaring birds are daily performing the feat, and apparently in horizontal winds.

In order that those who are favorably circumstanced may test the matter experimentally, the following description of the device is copied from a paper of Mr. *Lancaster*, published in 1882:

Take a stick of wood 1 in. square and 18 in. long, and point one end. Slit the other end 3 or 4 in., and insert a piece of stiff cardboard 6 in. wide and 1 ft. long. This will represent the body and tail of the bird. Fasten on both sides near the pointed end a tapering stick 2 ft. long, with the outer ends slightly elevated, and fasten to these and the body a piece of cardboard 10 in. wide and 2 ft. long. Have the tail vertical instead of horizontal, as in the bird. Round off the outer rear corners of the wings for 3 or 4 in. The imitation of the natural bird is now complete. There is no need of exactness, as the air you are to try it in will be an unknown quantity, and it may just suit the shape you make. An indispensable part is now to be added, which is to preserve the equilibrium and is not used by the natural bird. A tapering stick, say 1¼ in. wide, ⅜ in. thick at the top, ⅜ in. square at the other end, and 18 in. long is used. This piece is to be securely fastened by a small bolt through the upper end of the body piece about 5 in. from the front end. It must be capable of adjustment by allowing the lower end to swing front and back through say 40°. To the lower end is fastened a muslin bag which will hold 2 lbs. of shot. Expose the effigy to a breeze of from 3 to 20 miles an hour from as high a situation as it is possible for you to obtain, by holding it by the pendant stick near the body. Adjust the weighted stick forward or back, and add or subtract shot until the effigy has a tendency to spring from your hand against the current of air, when it may be released at a moment of greatest steadiness of breeze.

I have made hundreds of these toys, with all kinds of success, but have never yet succeeded in getting one to travel beyond the limits of vision. They have proceeded directly against the breeze for 500 yards, and obliquely, up or down, or to right or left, within those limits, when they would lose their balance and come down. Sometimes almost any kind of one that was presented to the air would float creditably, while at others none would succeed. The pendant weight for maintaining equilibrium, though the best I have ever devised, is far too sluggish for perfect work. The momentum of this weight prevents the best results, for, if a succession of puffs of wind upon the same wing should occur quickly together, the weight would swing far enough, in obedience to the impulse given, to capsize the effigy. Such a succession of puffs is sure to occur, sooner or later, at each trial. These toys operate long enough, however, to prove the purely mechanical character of flight, and serve to materially strengthen the theory.

The writer may confess that he has tried this experiment several times under special instructions furnished by Mr.

Lancaster, but that he has never succeeded in floating one of these "effigies" so that they would advance against the wind. Others have, to his knowledge, tested the matter, and had no better success, yet it is not rational to say that the feat is impossible, for it is very clear that if the wind have an ascending trend, and the "effigy" be slightly tipped toward the front, the horizontal component of air pressure will drag it forward, while the vertical component will sustain or elevate it, as already explained. It is probably because of the uncertain prevalence of ascending trends that Mr. *Lancaster* complains that sometimes almost all these toys would succeed in simulating soaring, and sometimes none at all.

In 1888 Mr. *Lancaster* moved to Colorado, where he has been experimenting with a view to the solution of the problem of soaring flight; and in the *American Naturalist* for September, 1891, he gave an account of some of his experiments, with the conclusions which he deduced therefrom. The following extract contains an account of a remarkable occurrence. He says:

I can produce true soaring flight in natural wind, with a plane exceeding 2 lbs. to a square foot of surface, whenever I wish to do so and can obtain wind strong enough for the purpose. During the past three years I have made about 50 planes [aeroplanes?] of various shapes and sizes, and from 25 lbs. to 400 lbs. in weight. These planes are not set free in wind, but used in the experimental cases above described, but with rigid rods in place of the parallel wires. These rods run in large rings and have a cross head at their outer ends allowing the plane to run to the front until its edge rests against the rings. In the best trial the parallel [with the plane?] component is neutralized at 10° from horizontal, far exceeding my expectations derived from observations of the birds, their angle of obliquity being rarely over 5°.

On a few occasions these planes accidentally escaped me in time of highest wind, and were ruined at once for all purposes excepting firewood, in each case being a loss of two or three months' work, and playing havoc with my finances. One that I valued particularly plunged to the front in a violent blast of wind with force sufficient to tear out the rings. It rose into the air gradually higher and higher, until an elevation of at least 3,000 ft. was attained, when some part of the device giving away, it lost equilibrium and plunged through the air, striking the earth about 2½ miles from the starting-point, and 1,000 ft. higher than that locality. Another mile would have carried it to the summit of the Flat Top Mountains. It was in the air about three hours, and I walked beneath it during its flight. Its course was directly against the highest wind I have experienced during my residence here. At times it did not progress, but went higher. It weighed 110 lbs., and had been well balanced for experimenting on surface manipulation. There was no lesson taught in this flight, the birds having been doing the same thing for a long time. It was an interesting spectacle to look at; so is a large bird in the same act. I presume Mr. Darwin's provisional solution would apply to this plane as well as to the condors; but I am trying to explain the actual mechanical activity of both.

The best effects produced were with a plane of 400 lbs. weight and 80 sq. ft. of surface. In a wind that would be rightly termed a gale, arising about midnight, this plane was thrown about 7° from horizontal. It ran to the front against the rings at 10°, where the entire parallel component was neutralized, and at 7° it hugged the rings with a force that required a backward pull of 15 lbs. to detach it.

This plane would make a splendid navigator, and I would have no hesitation in trusting myself to it, when steering, equilibrium and alighting or stopping items had been worked out. I mean to say that it would navigate wind. I am now just entering on a course of experiments in calm air.

This very interesting case of "aspiration" may have been produced by the same cause as in the case of M. *Myers's* kite—*i.e.*, an ascending trend of wind; but certainty concerning this depends upon the shape of the surface. Mr. *Lancaster* writes of it as a "plane;" but as he mentions also the "front ledge" and the "rear curve," the surface operated upon by the wind was probably a more or less compound surface, for which there is no specific name, but which may be described as an aeroplane. If it was shaped like those of the soaring birds, then "aspiration" might occur with a horizontal wind, but the equilibrium would be very unstable, and, as Mr. *Lancaster* points out, the steering, alighting, and stopping would be the important points to work out.

Among the most systematic and carefully conducted series of experiments that have ever been made in the direction of artificial flight are those of Herr *Otto Lilienthal*, of Berlin, Germany, a mechanical engineer and constructor, and a prominent member of the German Society for the Advancement of Aerial Navigation.

The general position that he maintains, and in pursuance of which he has made his more recent experiments, is that bird flight should be made the basis of artificial flight. Dexterity alone, as he maintains, invests with superiority the native denizens of the air, and, therefore, man, if he possessed sufficient skill, might participate in flight. He evidently believes, like M. *Mouillard*, that for the soaring birds, ascension is the result of the skillful use of the power of the wind, and that no other force is required; and, therefore, that to imitate them no engines or other external sources of power are needed, but that all the necessary apparatus consists of properly constructed sustaining surfaces skillfully operated.

Herr *Lilienthal*, instead of first flying at conclusions, began by a systematic analysis of the problem, verified by experiments, which latter were carried on by himself and his brother, *G. Lilienthal*, during a period covering nearly 25 years, and he published in 1889 a book on "Bird-Flight as the Basis of the Flying Art," * in which he gave the result of his investigations.

From a review of this remarkable book in the *Aéronaute* for January, 1892, the following account of its contents has been prepared.

Herr *Lilienthal* seems to have begun by observing the sailing of various sea birds following vessels at sea, and of the stork, an expert soarer, which inhabits Germany; he drew the conclusion that *plane* surfaces present undue resistance, and that success in artificial flight is only to be expected from concavo-convex sustaining surfaces; a belief which, as we have already seen, was also entertained by *Le Bris*, *Beeson*, *Goupil*, *Phillips*, and others.

He declares that the laws of air resistances and reactions which, unfortunately, are as yet but imperfectly known, form the whole basis for the "technique" or actual performance of flight, and that the shapes and methods of birds so completely utilize these laws and offer such appropriate mechanical movements that failure must follow if they be discarded.

Herr *Lilienthal's* experiments were in great part directed toward an investigation of the resistances and reactions of air, and the power necessary for flight. One of these consisted in suspending himself from a spar projecting from a house and operating a set of six wings opening and closing like concave Venetian blinds, through which he measured the lifting effects of wing strokes performed with the muscles of the legs, so that the step of each foot would produce a double stroke of the wing. The weight of the operator and wings combined was 176 lbs., and they were counterweighted with 88 lbs. suspended to a rope passing over two pulleys. With some practice he was enabled, by operating the wings with the pedals, to lift himself 30 ft. from the earth, thus proving that he obtained, through his mechanism, wing power sufficient to lift the remaining 88 lbs—a very excellent performance, and much in excess of most of those hitherto described in this review of Progress in Flying Machines.

This and other experiments, together with a consideration of the power to be obtained from the wind, convinced him that artificial flight was accessible to man, aided by considerably weaker motors than have generally been thought indispensable, and, indeed, under favorable circumstances of wind, with no motor at all.

Herr *Lilienthal*, therefore, carefully analyzed the shapes and methods of the living birds and the exact proportions of their concavo-convex surfaces. He went into this in detail, and finally formulated in his book the following conclusions:

1. The construction of machines for practical operation in nowise depends upon the discovery of light and powerful motors.

2. Hovering or stationary flight without forward motion cannot be compassed by man's unaided strength. This mode of

* "Der Vogelflug als Grundlage der Fliegekunst," Von Otto Lilienthal, Berlin, 1889.

flight would require him to develop, under the most favorable circumstances, at least 1.5 horse power.

3. With an ordinary wind man's strength is sufficient to work efficiently an appropriate flying apparatus.

4. With a wind of more than 22 miles per hour, man can perform soaring or sailing flight by means of adequate and appropriate sustaining surfaces.

5. A flying apparatus, in order to operate with the greatest possible economy, must be based, both in shape and proportion, upon the wings of the large, high-flying birds.

6. The sustaining wing surface may be from 0.49 to 0.61 sq. ft. per pound of weight.

7. Sufficiently strong apparatus can be built of willow frame and stretched fabric, so as to provide a sustaining surface of 107 sq. ft., with a weight of about 33 lbs.

8. A man provided with such an apparatus would have an aggregate weight of 198 lbs., and would then have 0.55 sq. ft. of sustaining surface per pound, or about the proportions of large birds.

9. Experiment must determine whether the most advantageous shape be that of birds of prey and of waders, with broad wings and spread out primary feathers, or that of sea birds, with narrow wings tapering to a point.

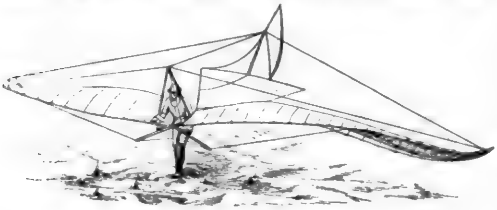


FIG. 73.—LILIENTHAL—1891.

10. If the broad wing be adopted, the wings of an apparatus with 107 sq. ft. of sustaining surface would needs be of 26.25 ft. spread, with a maximum width of 5.25 ft.

11. If the narrow wing be adopted, a surface of 107 sq. ft. would need a spread of 36 ft. with a maximum width of 4.60 ft.

12. The application of an additional bearing surface, as a tail, is of minor importance.

13. The wings must be curved in transverse section so as to be concave on the under side.

14. The depth of flexure should be one-twelfth of the width, in order to correspond with that of birds' wings.

15. Experiment must determine whether greater or lesser flexure will prove preferable for larger wing surfaces.

16. The framing and spars of the wings should be at the front edge so far as possible.

17. A sharp cutting edge should terminate this framed front edge if possible.

18. The flexure should be parabolic, the greater curvature being to the front and flatter to the rear.

19. The best shape of flexure for large surfaces must be determined by experiment; also what preference is to be given to those shapes which produce the least resistance to forward motion at flat angles of incidence.

20. Construction must be such as to admit of the rotation of the wing upon its longitudinal axis, which rotation will best be obtained, in whole or in part, by the pressure of impinging air.

21. In flapping flight the inner wide portion of the wing should oscillate as little as possible, and serve exclusively in sustaining weight.

22. The propulsion to maintain speed should be obtained by up-and-down beats of the wing tips or of the primary feathers, the forward edge being depressed.

23. In flapping flight the widest portion of the wing must also co-operate in the upstroke in order to sustain weight.

24. The wing tips should encounter as little resistance as possible on the up stroke.

25. The down-stroke should be in duration at least six-tenths of the time occupied by the double stroke.

26. The wing-tips alone need oscillate; that portion of the wing which merely sustains may remain rigid, as in soaring flight.

27. If only the wing-tips oscillate they should not be articulated, as this would dislocate them; moreover, the transition to the up stroke should be as gentle as possible.

28. In order to beat a pair of wings, man must employ his extensor muscles, and this not simultaneously, but alternating each side, so that each stroke of the foot shall produce a double stroke of the wings.

29. The up stroke may be produced by the pressure of the air under the wings.

30. The energy of the air pressure under the wings may be partly stored in a spring so as to restore the power on the down stroke, and thus produce economy in work done.

Such are the principal considerations which must be observed in the application of the theories herein expounded. . . .

Governed by these considerations, equipped with much preliminary experiment and analysis, Herr *Lilienthal* put his theories and conclusions to practical test, in the summer of 1891, by undertaking a series of experiments with a pair of curved wings designed for soaring alone—that is, to serve as sustaining surfaces and not for flapping or propulsion.

The following account of these experiments has been furnished by Mr. *George E. Curtis*, of Washington, D. C., who has also obtained from Dr. *C. Kassner*, of the Meteorological Institute at Berlin, the very graphic photographs from which the engravings have been made.

The *Lilienthal* apparatus is shown in fig. 73, and consists of a pair of extended bird-like wings, incurvated from front to back on parabolic lines, and sinuous in the direction of their lengths. The area of sustaining surface, as at first constructed, was 107 sq. ft., but it was diminished in the course of numerous changes and remodellings to 86 sq. ft. There was, as will be observed, a horizontal tail and a vertical rudder or keel. The framework was made of willow, and covered with sheeting fabric. The weight of the whole apparatus, without the operator, was 39.6 lbs.

In order to become accustomed to the management of these artificial wings, Herr *Lilienthal* first practised in his garden. Here he had a spring-board, toward which he ran for a distance of about 26 ft.; and with the velocity thus acquired, together with the reaction of the spring-board, he launched himself into the air, where he could learn to operate and to manage the wings.

After these preliminary experiments had given him dexterity and facility in the management of the apparatus, he betook himself to a hilly region in the suburbs of Berlin, and there practised soaring flight in natural winds of moderate velocities. The plan, of course, consisted in first running against the wind, and thus deriving therefrom the necessary sustaining air pressure.

Having selected a hill whose downward inclination faced the prevailing wind, he ran along the summit straight toward the wind, until a sufficient velocity was attained at the brow, where he was carried into the air and landed safely at the foot of the hill, having sailed a distance of 65 to 82 ft.

When the wind velocity became greater than 11 to 13 miles per hour, the management of the apparatus became exceedingly difficult, and Herr *Lilienthal* advises an experimenter not to venture to leave the ground under such circumstances, unless he has attained, through long practice, a considerable degree of dexterity in manœuvre.

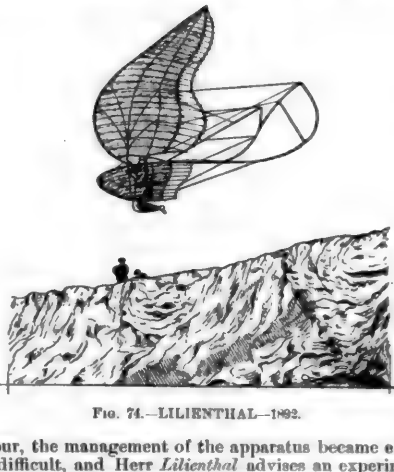


FIG. 74.—LILIENTHAL—1892.

The results attained in the practice of the season of 1891 were sufficiently encouraging to warrant the further prosecution of these experiments in the following year; but they disclosed a number of points to which additional attention

needed to be given in order to overcome the practical difficulties in imitating the birds. These points related to a better adjustment of the center of gravity, to methods for obtaining greater stability, and to the mode of management of the apparatus when the wind blew more rapidly than 11 to 13 miles per hour.

In the issue of the *Zeitschrift für Luftschiffahrt* for November, 1892, Herr *Lilienthal* published an article on "Soaring and its imitation," in which he gives a brief account of his experiments in the summer of 1892, from which the following abstract has been prepared :

Many theories have been proposed to explain soaring. My own explanation is based upon the advantageous relations of air resistances incident to the use of slightly curved wing surfaces (as I have demonstrated) and upon the gently rising trend of air current which I have found to prevail.

A flying apparatus which has the same proportions as those of a good soaring bird and is of sufficient size to carry a man can scarcely be held fast by three or four men together when exposed to a brisk wind. When we look at the safe and quiet sailing of the birds it almost seems as if some undiscovered mechanical principle were at work, some feature in the elastic properties of air or in the elastic curvature of the feathers which accounts for the mystery of sailing flight ; but my experiments have taught me that there is no mystery, and that the same mechanical science which has explained the theory of the steam-engine and followed the orbits of the planets is adequate to explaining the operations of soaring flight.

Dexterity alone, in my opinion, invests the native inhabitants of the air with superiority over man in that element. . . . Inasmuch as continuous soaring with large wings in high winds can terminate in scarcely anything but the destruction of the foolhardy fellow who may first attempt the experiment without previous practice, I first undertook last year to gain some expertness with a smaller apparatus and in moderate winds. In spite of my caution the wind several times played the mischief with me. Even with only 86 sq. ft. of sustaining surface, I was several times tossed up into the air by unexpected gusts of wind, and but for the circumstance that I was able to release myself quickly from my apparatus, I might have had a broken neck instead of the sprains in feet or arms which always healed in a few weeks.

Almost every Sunday, and sometimes on week days, I went out to practise on the hill between Grosskreutz and Werder. A mechanic, Herr Hugo Eulitz, the maker of my apparatus, went with me, and each practised alternately while the other rested. Thus we obtained dexterity in gliding down on the air and in landing at the foot of the hill without mishap.

Herr Kassner, of the Meteorological Institute, was so kind as to photograph me in the air, and has thus enabled me to exhibit to the members of the society how I sailed right over the head of the miller of Derwitz (in whose barn I stored my apparatus) and of his esteemed poodle dog.

Equipped with the experience gained in 1891, I this year attempted to soar with wings measuring 172 sq. ft. in surface. My apparatus weighed 53 lbs., and my own weight is 176 lbs., so that the whole was 229 lbs. Each square foot of surface, therefore, sustained $229 \div 172 = 1.33$ lbs.

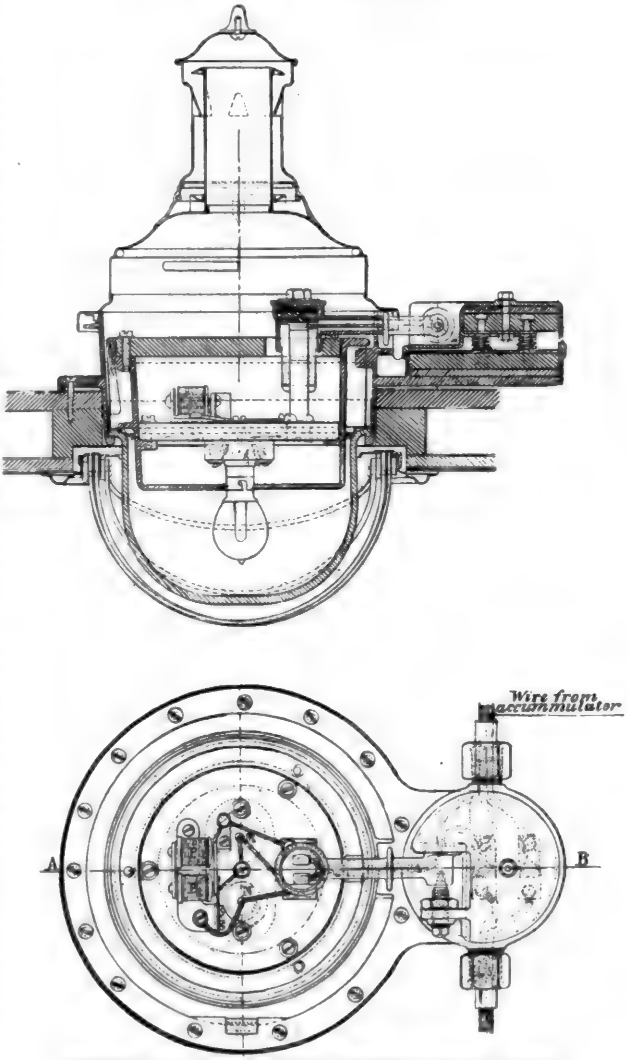
The up thrust of the wind (the lift) upon the wing surface is perhaps half as much as the pressure of the same wind upon the same surface if turned perpendicular thereto.* Now, as the apparatus therefore needs to sustain it a wind producing a pressure of $1.33 \times 2 = 2.66$ lbs per square foot, we see that (by ordinary tables of wind pressures) it must blow at a velocity of about 23 miles per hour.

I have, however, been very cautious about exposing myself to such a wind with this large apparatus ; and in such high winds have used smaller surfaces for my sailing practice.

This year I selected a locality between Steglitz and Südende. It had, however, the disadvantage that only westerly starts were possible. Herr Kassner has again taken instantaneous photographs of my apparatus, which have been laid before the society (fig. 74). The strongest winds in which I practised had a velocity which I estimated at between 15 and 16 miles per hour. By running I obtained an additional velocity of 7 miles an hour, making the total relative velocity 23 miles an hour, which was required for soaring. Under these circumstances the first part of my flight was almost horizontal, and the alighting was always a gentle one. . . . Each apparatus had a vertical and horizontal tail, without which it is impracticable to practise in the wind. In conclusion, I will remark that sailing flight near the earth's surface must be much more difficult than at greater heights, where the wind blows more regularly, while every irregularity of the ground at lower levels starts whirls in the air.

(TO BE CONTINUED.)

* Lilienthal, "Der Vogelflug als Grundlage der Fliegekunst," Tafel VII.



ELECTRIC LAMP, PARIS, LYONS &, MEDITERRANEAN RAILWAY.

ELECTRIC LIGHTING ON THE TRAINS OF THE PARIS, LYONS & MEDITERRANEAN RAILWAY.

In our issue for March we gave a short description of the method of electric car lighting in use on the Northern Railway of France, supplementing the same in our April issue by a description of the system in use on the Jura-Simplon Railway.

We now reproduce from *L'Electricien* a description of the system of lighting which has been brought on the Paris, Lyons & Mediterranean Railway.

The Paris, Lyons & Mediterranean Railway Company are making a test of electric lighting on 50 first-class four-compartment passenger cars. A portion of these cars are already completed, and the whole will be put into regular service with the new method of lighting, the plant for generating electricity for charging the accumulators being located at the Paris station, and it will be very soon completed. This application of electric lighting has been decided upon by the company in consequence of the numerous experiments which have been carried out during the last three years with primary and secondary batteries, the latter of which will be used for the new work.

The accumulators adopted are of the Tommasi multitubular system, with electrodes protected by a perforated envelope of celluloid. Each cell carries 26.5 lbs. of electrodes.

Each car is provided with a battery of 12 cells set up under tension and divided into four groups of three cells each. Each group is placed in a tight box of three compartments, which is in turn placed in a sheet metal chest lined on the inside with wood, all the movable boxes being interchangeable.

The chests are fastened one on either side of the car just opposite the pedestal brace. They are provided with a hinged horizontal door which turns down so that the tight box containing the three elements can be very easily removed or put in position. The connections are made automatically by means of contact points in the case and the box. For this purpose the latter has brass springs which are permanently connected with the wiring of the car; the poles of the group of the three cells end in two metallic pieces of an alloy of antimony and lead fixed to the case and projecting so as to turn against the springs, thus putting the group into the circuit when the case is set into the box. Insulated wires enclosed in iron tubes serve to make connection between the contact springs of the four boxes of the car. The tube containing the insulated wires runs along close to the frame and beneath the body of the car, and comes together at the ends of the car, whence they run to the lighting commutator. Switch connections are used to make and protect the connections between the insulated wires and the springs of the boxes. Incandescent lamps of 10 candle power have been adopted, and a difference of potential limited to 20 volts will be used. Each of the four compartments of the car is lighted by one of these lamps. The lamps are of the ordinary model, and are so arranged that oil gas can readily be substituted for the electric lighting in case the latter should for any reason become useless, and that, too, without disconnecting any of the apparatus. In order to do this the electric lamps are mounted upon a movable support which can be readily substituted for an oil lamp or *vice versa*.

The current is brought to the lamp through a bi-polar lever, which is usually turned down beneath the cap of the lamp, and which it is merely necessary to lift up in order to very easily remove the whole of the support. This support carries two incandescent lamps, only one of which is usually lighted; the second serves as a reserve lamp, and is lighted automatically if the first should become accidentally extinguished. This automatic arrangement is accomplished by an electric magnet, *P*, fig. 1.

If we take the average consumption of each lamp as 38 watts, the battery of accumulators can feed four lamps of a car for about 35 hours. The accessory apparatus consists of three parts: The lighting commutator, the rheostat, and the meter. The lighting commutator into which the two conductors come from the batteries possesses no special features. It is arranged in the same way as the main cock of cars lighted with oil gas. It is controlled by a handle sliding along end supports and into the intermediate supports.

The rheostat, which is placed in the lamp circuit, is to compensate during the early part of the discharge for the excess of voltage of the battery over what is necessary for the normal illumination of the lamps. By connecting it with the indications furnished by the meter, it is put out of circuit when the lighting has been in operation for 17 hours—that is to say, at about half of its normal duration.

The meter is constructed on the Aubert system, which is the one which has already been adopted on the Jura-Simplon Railway. The dial is divided into 35 divisions corresponding to the 35 hours, during which the batteries are capable of operating. The pointer is so arranged that it moves from division 35 to division 0, and consequently indicates the number of hours lighting which the battery is still capable of furnishing. This meter is placed in the same position as the pressure gauge of the cars which are lighted with oil.

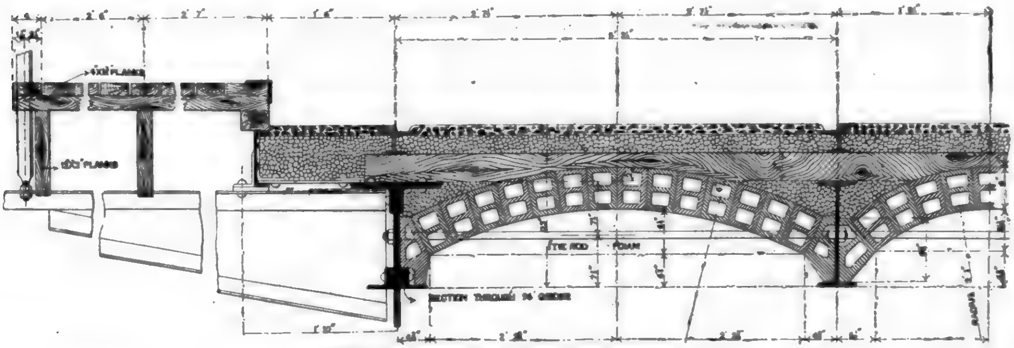
Wiring for the lamps is identically the same as that for the accumulators, and is contained in two insulated cables enclosed in an iron tube. These two cables, starting from the commutator, pass through the meter, the rheostat, and run to the roof of the car, where they enter the switch boxes that are placed near each lamp, and within which the connection between the wires from the lamps and the main line is made.

The apparatus of each first-class car, therefore, consists of eight incandescent lamps, four of which are auxiliary lamps, the battery accumulators of four nests of cells, which weigh 505.7 lbs., and is composed of:

Electrodes alone, 346.9 lbs.

Boxes and cases, 158.8 lbs.

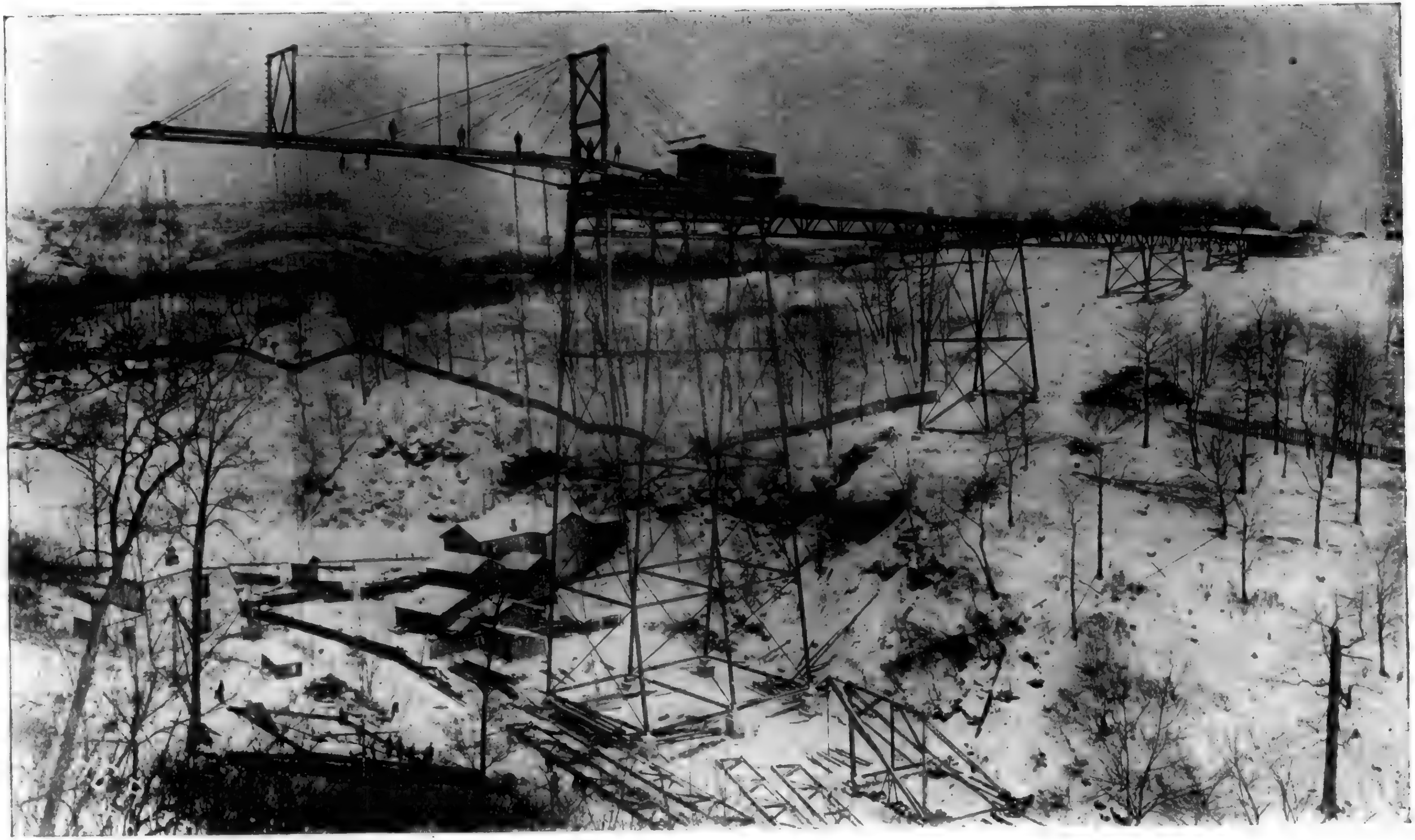
The rest of the apparatus, comprising the main box for carrying four cases of accumulators, the wiring commutator, rheostat, meter and lamps, represent a total weight of about 1,098 lbs. The total capacity of the battery of four nests of cells is about 5,600 watts, which represent 36 hours of lighting for the whole four lamps, admitting that each has a consumption of 38 watts per hour.



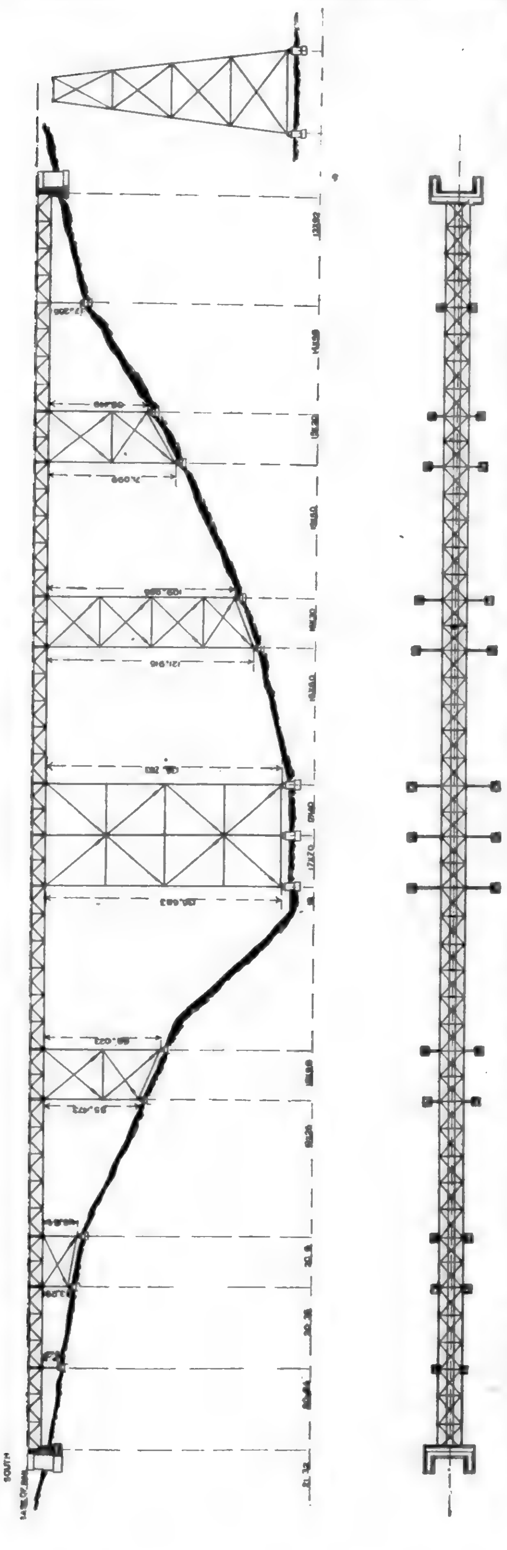
SECTION OF FLOOR OF JACK'S RUN BRIDGE.

THE CAOUTCHOUC INDUSTRY OF ASSAM.

THE Calcutta *Englishman* states that a change has been recommended in the present regulations affecting the sale of caoutchouc in the Government forests of Assam. Owing partly to the reckless method of working adopted by contractors and their agents, and partly to the depredations of illicit tappers, there has been a serious falling off in production. The unprotected and inaccessible situation of most of the rubber tracts enables the neighboring hill tribes to illicitly tap the trees and import the rubber into Assam free of duty as foreign produce. It is stated that the Government forests on the frontier are overrun with foreign rubber tappers, who come down systematically by night in separate gangs, each under a sardar, and tap nearly all the trees growing within a few miles of the border. The leases to contractors have, however, now expired, and a scheme for the better protection of the forests is now under consideration. On the average about Rs. 30,000 has been derived annually from this source during the past 10 years, and under an effective system of administration the revenue could doubtless be largely increased.



JACK'S RUN VIADUCT, ON THE PITTSBURG, FORT WAYNE & CHICAGO RAILROAD. BUILT BY THE SCHULTZ BRIDGE & IRON CO., OF McKEE'S ROCKS, PA.



JACK'S RUN VIADUCT.

The borough of Bellevue is located on the steep northern heights of the Ohio River, over 200 ft. above the river, having a station at the Pittsburg, Fort Wayne & Chicago Railroad in the valley 6 miles distant from Pittsburg.

For the ascent to the hilltop seven years ago a passenger elevator was built, which lands its passengers a good distance from the principal part of this thriving place.

The increasing necessity for close communication of this suburban borough with the cities of Allegheny and Pittsburg would have resulted long since in an extension of Pittsburg's electric car lines, had it not been for the steep valley of Jack's Run at the boundary line of the city of Allegheny.

Last year California Avenue was extended from Allegheny to the edge of this valley to a point about half a mile distant from the place where Jack's Run empties into the Ohio River; at the same time the Pleasant Valley Street Railroad Company laid their tracks along this avenue to Jack's Run, and decided to extend their line still further to the central part of Bellevue and Avalon, for the accommodation of their citizens, and in consequence to connect both edges of Jack's Run valley by a steel viaduct more than 700 ft. long and over 150 ft. high.

This Company had a line surveyed and adopted the plan of the Schultz Bridge & Iron Company at McKee's Rocks, Pa., to which company they awarded the contract for building this bridge.

The viaduct has six spans of 30 ft., two spans of 48 ft., two spans of 64 ft., three spans of 80 ft., and one span of 96 ft.

The girders of these spans have a uniform height of 8 ft., and support a roadway of 17 ft. between curbs and two sidewalks of 5 ft. The track rails are fastened to oak cross-ties 4 in. high; these rest upon stringers or upon girders acting as such, so that the distance center to center of girders is 14 ft., which is also the width center to center of bent posts at top of bents, from where the posts spread toward the ground, with a batter of $1\frac{1}{2}$ in. to the foot. All floor, girder and bent connections are riveted; only the tower rods are pin connected.

The 30-ft. girders bridge the tower spans, which have from one to four stories; at the deepest place of the valley a double tower is located.

The strains in the structure have been based on the following assumptions:

Dead load:	Roadway floor,	60	lbs.	per square	foot.	
	Sidewalk "	15	"	"	"	
	Stringers	100	"	lineal	"	of span.
	Floorbeams	100	"	"	"	"
	30-ft. girders	160	"	"	"	"
	48-ft. "	240	"	"	"	"
	64-ft. "	320	"	"	"	"
	80 ft. "	400	"	"	"	"
	96 ft. "	480	"	"	"	"

Live load: 80 lbs. per square foot of roadway and sidewalk, respectively, electric cars of 12 tons, 20 ft. long, 6 ft. wheelbase.

Wind pressure for top laterals: 300 lbs. per lineal foot of span, 150 lbs. of these treated as moving load.

Wind pressure for trestle towers: 400 lbs. per lineal foot of span and 150 lbs. per rising foot of bent.

For the proportioning of section unit strains have been taken is follows:

Tension on lateral bracing, 15,000 lbs. per square inch; on bottom flange at riveted girders, 14,400 lbs. per square inch, net section; on fiber most strained in I-beams, 16,000 lbs. per square inch; on bottom chords and diagonals, 11,100 lbs. per square inch for live load, and 22,200 lbs. for dead load.

Compression in girder members:

P, 8,750, 50 $\frac{1}{r}$ for live load strains;

P, 17,500, 100 $\frac{1}{r}$ for dead load strains;

P, 17,100, $\frac{1}{r}$ in posts and struts of bents;

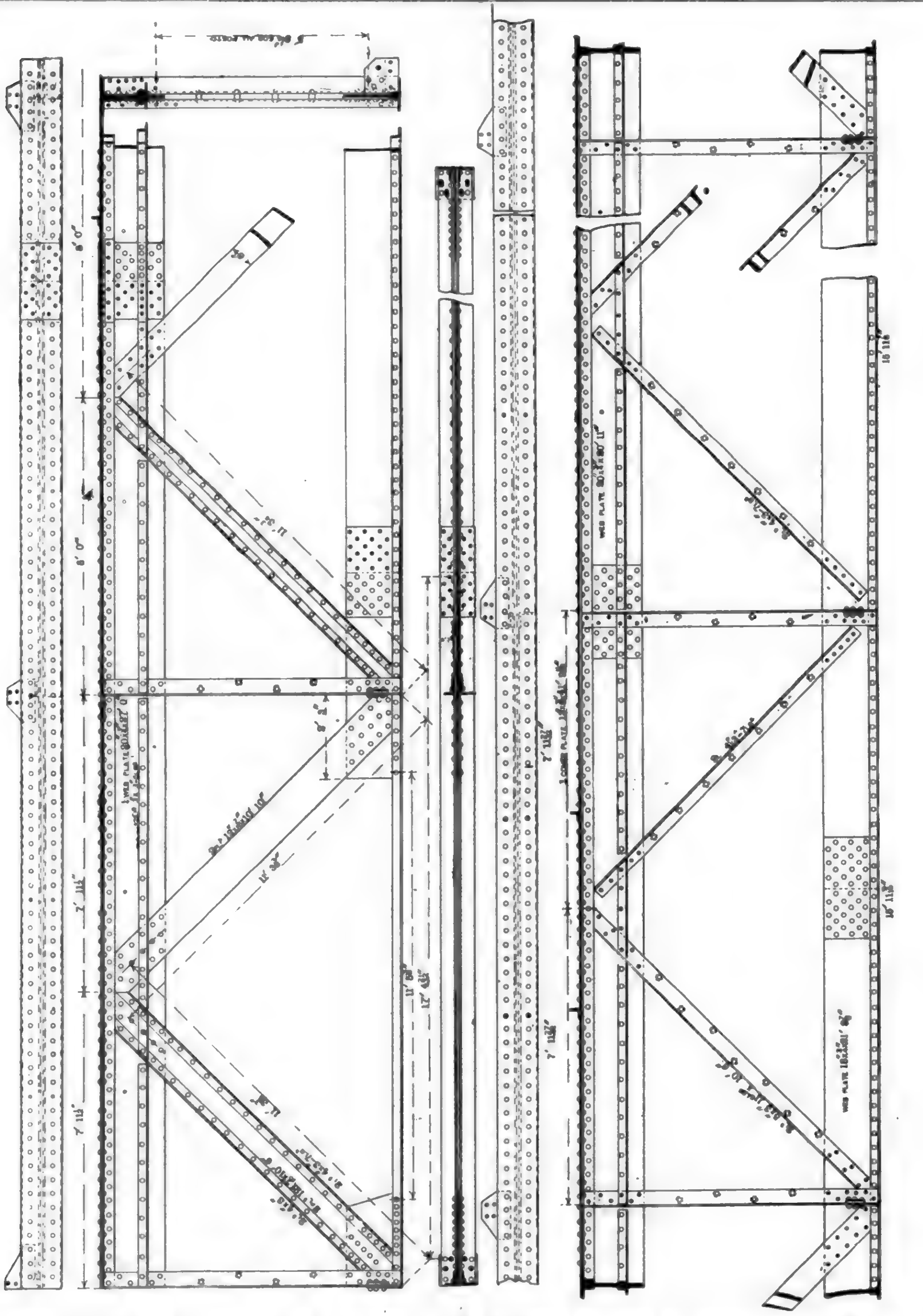
where P indicates the allowed compression per square inch of cross-section.

1, the length of compression members in inches.

R the least radius of gyration of the section, in inches.

Maximum fiber strains of white pine joists, 12,000 lbs. per square inch.

The structure was completed three months after approval of the plans, and even the extremely cold weather of last winter did not delay the erection, which began in December, 1892, at the Allegheny side, and reached a month later the Bellevue end.



No false work was used; all material was put in place by use of a traveling derrick with a projecting arm 115 ft., long enough to put a bent at the far side of the longest span.

The half-tone engraving shows the traveler in this position; it stands upon the double tower, ready to put the lower part of the tower at the far side of the 96 ft. span; the height of the projecting arm above the bottom of the valley is a little over 160 ft.

The total length of this traveler is 173 ft.; the height of its principal bent, 35 ft.; its width, 14 ft. The engine, 14 ft. long, stands as counter weight 44 ft. behind the saddle bent, and has an additional load of 40 cross-ties at each side of the

engine; the total weight of iron and timber in the traveler, the engine, the cross-ties and about 10,000 ft. of ropes, including blocks attached to the traveler, amounted to 57 tons.

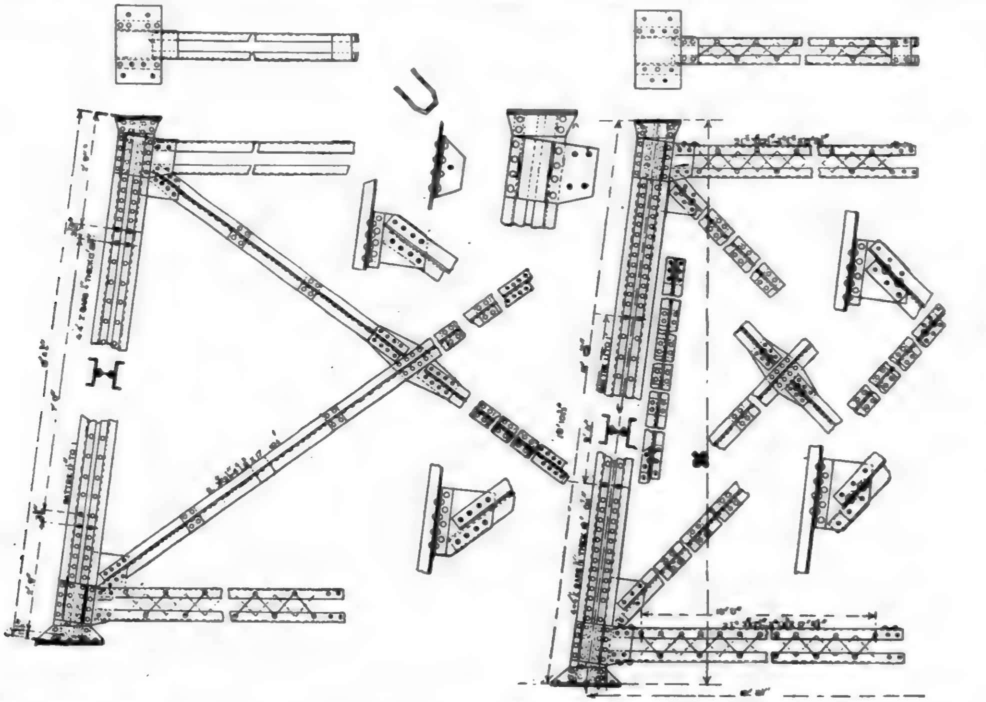
For the purpose of getting a massive roadway floor, 6-in. arches of sharp burned hollow brick are to be built between the stringers; they are to be covered with concrete and with a top layer of asphaltum the height of the track rails. Temporarily a wooden floor has been laid.

The sidewalk will be planked.

The total amount of first-class masonry in abutments and piers is about 400 cub. yds., and of steel structure, 375 tons. The total cost will be $60,000.

The work was done by the Schultz Bridge & Iron Company of Pittsburg, Pa.

liquid on an asbestos filter in a platinum boat, taking pains at the last to pour out all the liquid, and at the same time leave as much of the separated carbon in the beaker or dissolving jar as possible. Now add about 10 c.c. of dilute hydrochloric acid [sp. gr. 1.1] to the beaker or jar, and so manipulate that this acid shall touch all parts of the beaker or jar which has been in contact with the solvent liquid. Pour this acid on the filter, and wash the carbon out of the beaker or jar by means of a wash bottle containing the same strength acid. Continue the washing with the acid until all color has disappeared from the washings, and then wash with water until the washings no longer react for hydrochloric acid. After the washing is complete the filtrate should be poured into a large beaker and diluted with clean water, and acid added, if necessary, to hold



CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

I.—METHOD OF DETERMINING CARBON IN IRON AND STEEL.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page 253, Volume LXVII.*)

OPERATION.

Put 3 grams of fine borings of the iron or steel in a 16-oz. beaker or pint dissolving jar, and add 200 c.c. of an acid solution of the double chloride of copper and potassium which is at a temperature not above 100° F. Allow to dissolve, taking pains to agitate the liquid during solution. As soon as the separated copper has all disappeared, allow to stand a little while to settle if necessary, and then pour the supernatant

the sub-chloride of copper in solution, until it is possible to see whether any carbon has escaped the filter. If any is found, of course the liquid must be passed through the filter again, or the material all thrown away, and a fresh start made. Dry the carbon at a temperature not above 212° F., and then place the boat with the dried material in it in the combustion furnace. While the drying is going on, weigh the absorption potash bulb and prolong, which have been previously prepared as described below, and place them in their proper position, in connection with the combustion train, which has likewise been previously prepared as described, and in which the preheating furnace has been lighted long enough, so that its porcelain tube is fairly red, for at least 5 or 6 in. of its length. Start the combustion by turning on enough burners at the front end of the combustion tube to embrace about 3 in. of it with flame, and at the same time see that the connection to the air gas holder is closed, and then open the connection between the oxygen gas holder and the combustion tube, and then adjust at the aspirator so as to allow about three bubbles a second to show in the absorption potash bulb. As soon as the combustion tube above the burners already lighted becomes perceptibly red, turn on enough more burners to embrace a couple of inches more of the tube, and allow this portion likewise to become perceptibly red. From this point turn on one or two burners at a time, allowing the tube above them to get red before turning on more, until enough have been turned on to heat the tube red a couple of inches toward the rear end from where the boat lays inside. Continue the combustion after the last burner is lighted, about 15 minutes for steel and not less than 30 minutes for pig or cast iron, taking care to keep the

flow of oxygen to the combustion tube sufficient to maintain a slight pressure in this tube, and at the same time not allow over about three bubbles per second to pass the absorption potash bulb. After the burning is completed, turn down the gas supply to the burners by means of a cock one-half, or turn out every other burner so as to allow the combustion tube to cool down slowly, and then shut off the oxygen supply and turn on the air supply for aspiration. Allow not less than a liter of air to pass through the absorption potash bulb, at a rate of not over three bubbles a second. While the aspiration is going on, diminish the gas supply to the burners by means

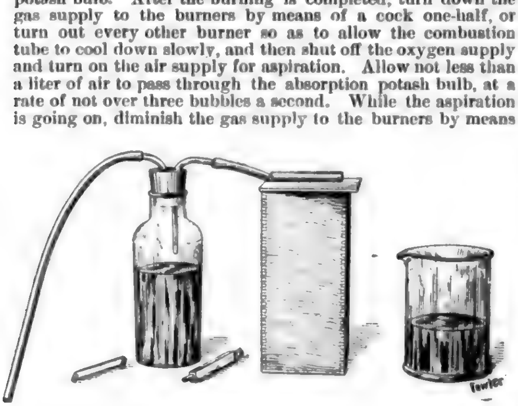


Fig. 1.

of the cock, or turn out additional ones as fast as the tube will stand it. When the aspiration is complete, detach the potash bulb and prolong from the furnace, close the ends with rubber caps, and place in the balance case. Allow to stand 15 minutes, and then weigh.

APPARATUS AND REAGENTS.

We prefer to use, in dissolving the iron or steel, a jar of thick, heavy glass, rather than a beaker. The jars we have found useful hold about a pint, and have a nose for pouring. One is shown in fig. 1.

about 40 in. long. The two horizontal parts at the top of the frame are perforated with ⅜-in. holes 5 in. apart each way, which holes, without any bushing, serve as bearings for the hollow tubular shafts. The top of each shaft carries a wooden pulley 4 in. in diameter, which has a brass bushing and set screw by means of which it is fastened to the shaft. Brass washers between the pulleys and the top of the frame carry the weight of the revolving parts and diminish the friction. A little tallow and graphite on the rubbing surfaces is also valuable for the same purpose. We use an electric motor for power, and the glass stirring rods revolve about 400 revolutions per minute. By taking care to wash the stirring rods both before and after using they may be adjusted once for all and left in position. The beakers or dissolving jars are supported on wooden blocks of the proper height, which blocks are movable, so as to allow the beakers or dissolving jars to be put in position or removed from the same without difficulty. With this stirring apparatus and the amounts of material previously prescribed, complete solution takes place in from 7 to 45 minutes, depending on the size of the borings and the nature of the steel or iron.

As will be seen by the cut, fig. 1, the devices for filtration consist of a receptacle to receive the filtrate, which is connected at the outlet with the exhaust pump or suction, and at the inlet with the platinum boat. The platinum boat is about 3 in. long, ½ in. wide at top, $\frac{7}{16}$ in. wide at bottom, and about ⅜ in. high. It is fitted with a perforated false bottom, which leaves a clear space underneath it of about ⅛ in. The boat is also fitted with a tubular opening at one end, which serves both as a means of connection to the inlet of the filtrate receptacle, and also as a passage-way from the boat for the filtrate. The boat rests on a clean glass plate, supported on a block, which glass plate serves to catch anything that may escape from the boat during filtrations, with a chance to recover the same if desired. This form of boat is as efficient as any we have ever seen, and seems to give less difficulty about keeping tight joints than those with perforated bottom. They may be obtained by special order from any dealer in chemical platinum.

The asbestos which we have found to give best results is the mineral known as "actinolite." We consider it essential to ignite the material as received after it has been picked up and

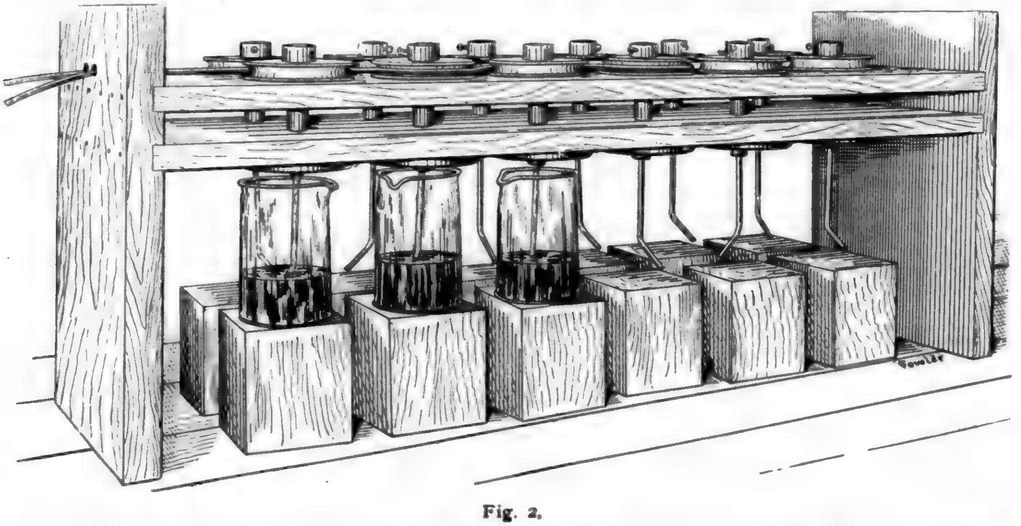


Fig. 2.

The agitating apparatus shown in fig. 2 consists, as will be seen, of a slight modification of the well-known stirring machine shown in the Chemical Analysis of Iron, by A. A. Blair, arranged to stir 12 beakers at once. The shaft carrying the stirring rod consists of a ⅜-in. diameter brass tube, carrying at the bottom a disk which revolves with it. This disk, which is 4½ in. in diameter and slightly turned up at the edges, serves very satisfactorily as a cover to the beakers in place of the perforated glass plate. The disk should revolve within about ⅛ in. of the top of the beakers. The hole in the brass tube used as a shaft serves to receive the cork carrying the glass rod, which, as is observed, is bent at the lower end so that it will just nicely revolve in the beakers or dissolving jars. The frame of the apparatus is made of wood about 11¼ in. wide and

cut with shears into short lengths, either in a platinum dish over a Bunsen burner, or in the combustion tube itself, in a current of oxygen. After a quantity of the ignited material has been prepared it should be mixed with water in a beaker and kept under cover as stock supply. To prepare the filter in the boat everything is put in position just as for a filtration and the suction started. The asbestos and water mixture, which should be pretty well diluted, is first stirred up well, in order to make some of it float, and then poured on the boat its whole length, taking care to have the asbestos evenly distributed. The suction removes the water as fast as it is poured on, and shows where to pour next. A filter about $\frac{1}{16}$ in. thick seems to work very satisfactorily. It is usually not necessary to make a fresh filter after each combustion, espe-

cially if the copper is completely dissolved before filtration, and if proper care is taken to wash the carbon clean. Under these conditions the same filter may be used over and over again by simply scraping off a little of the top and freshening it up with a little of the asbestos and water mixture after each combustion.

The drying of the carbon on the filter may be done either in the well-known drying oven with hot water or in the drying oven with hot air. We use the latter with an automatic regulator on the gas supply to maintain constant temperature.

The combustion train is shown in fig. 3. Beginning at the left hand, first are two gas holders, one for oxygen gas and the other for air. These are simple copper gas holders, with movable weights for pressure. They are adjusted so that the pressure will just cause the gas to bubble through the purifying potash bulb next to the combustion furnace, but not cause it to pass through the bubble tube containing iron sulphate just to the right of the combustion furnace. The connection between these gas holders and what we call the preheating furnace is by means of rubber tubes and a glass Y-tube. These rubber tubes should, of course, be closed by a cock or clamp, so that gas can be taken from either without contamination from the other. The preheating furnace is, as will be observed, a simple 12-in. Fletcher furnace, fitted with a porcelain combustion tube ¾ in. in diameter and 20 in. long, which contains granulated oxide of copper for about 8 or 10 in. of its length inside the furnace. A second combustion furnace would do equally well for a preheating furnace. The corks used with this and also with the combustion furnace are rubber; also rubber tubes are used for connections. The placing of the porcelain tube in the preheating furnace should be such that not less than 4 or 5 in. of its length projects toward the combustion furnace, so that this end may not become heated, with consequent danger of volatilizing hydrocarbons from the rubber cork; also, to prevent overheating of the porcelain tube, the gas holes in the gas tube of the preheating furnace are stopped up about 2½ in. each way from the ends. Next beyond the preheating furnace is an ordinary Geisler potash bulb, which may be called the purifying potash bulb, properly filled with caustic potash solution, to retain any carbon dioxide that may be in the oxygen or air used, or that may be formed in the preheating furnace from the combustion or any vapors containing carbon in these gases. The connection between this potash bulb and the porcelain tube in the preheating furnace should be so arranged that the glass tubes, which are embraced with the rubber tube at the joints, should have square ends, and should touch, so as to avoid exposure of the current of gas to the rubber tube as much as possible. This same remark applies to all other rubber tube connections. Next beyond the purifying potash bulb is the combustion furnace. The 14-in. Bunsen furnace gives excellent results. We use coal gas for fuel. The combustion tube is royal Berlin porcelain, glazed inside and outside, ⅝ in. internal diameter, and 24 in. long. The tube should be placed symmetrically in the furnace—that is, should project 5 in. at each end. It should be prepared for use by placing a small plug of asbestos or three or four disks of copper gauze, which are large enough to fit tightly at a point 6 in. from the right-hand end of the tube. Then put in granulated oxide of copper, followed by another asbestos plug or copper gauze disks for 4½ in. toward the left-hand end of the tube. Then make a roll of metallic silver foil, 2 in. long, rolled moderately closely, until it almost fills the bore of the tube, and place this next to the material already in the tube. This leaves abundant space in the tube for the boat, which should be pushed in so as to touch the silver roll. Next beyond the combustion tube is a bubble tube, not quite half full of acid ferrous sulphate solution, which serves to catch any free chlorine which may escape from the combustion tube, and next beyond this is a bubble tube, not quite half full of silver sulphate and water, which serves to catch any hydrochloric acid that may come out of the combustion tube, or from the ferrous sulphate bubble tube. The solubility of the silver sulphate being rather meager, it is desirable to add some of the solid salt to the bubble tube in order to prevent the necessity of too frequent charging of this tube. Next beyond the silver sulphate bubble tube is an ordinary chloride of calcium tube. In order to save space, we prefer the U form. Next is the absorption potash bulb. We prefer the Geisler form, and have them made so that when filled they, with the prolong, weigh from 50 to 60 grams. The ordinary size weighs from 80 to 90 grams. Next is the prolong, which is simply a small chloride of calcium tube filled with granulated chloride of calcium only. Next is another ordinary chloride of calcium tube to protect the prolong from moisture from the aspirator bottle. This bottle finishes the train. It is provided, as will be observed, with inlet at the top and side outlet at the bottom, which latter is also provided with glass tube of sufficient length to give the necessary suction, and a clamp on the rubber hose connection to regulate the flow.

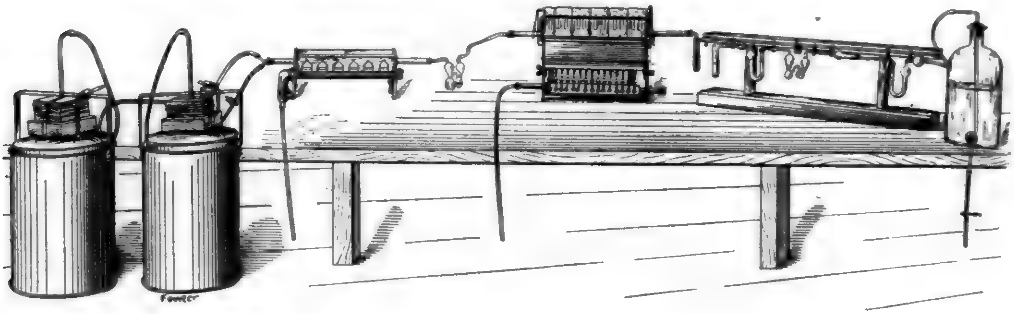


Fig. 3.

(TO BE CONTINUED.)

PHILLIPS'S FLYING MACHINE.

In our issue for June we presented illustrations of Phillips's flying machine, taken from *Engineering*, which give a very good idea of the general appearance of the machine. Since the publication of the above there has appeared in the London *Times* a description of the machine which, in some respects, is more complete than the one that we have already printed. We reproduce the more interesting details taken from the *Times*, referring our readers to our June issue for the illustrations of the machine.

The machine is built upon the principle of being sustained in its flight by means of induced currents acting upon slats or laths of wood arranged similarly to those of a Venetian blind, instead of the larger aeroplane to which designers of flying machines have usually had recourse. Not but that Mr. Phillips has used inclined planes, and used them of large size, too, but he has reduced their dimensions step by step, until the transverse sectional area of one of his present sustainers measures only 1½ in. in breadth by ¼ in. in thickness at the front, tapering to nothing at the back. Broadly stated, the cross section of the slat is that of a knife-blade, with a thick edge at back and a thin one at front, and with the upper and under side of the slat curved, but both differently. The form, in fact, is such that when the machine is in motion the convex upper surface near the front or thick edge deflects the air upward, thus creating a partial vacuum on the upper surface of the slat. The under or concave surface of the slat is formed to a parabolic curve, which gradually puts the particles of air into motion downward, thus producing an excess of pressure on the under side of the slat. It thus follows that upon a forward motion being given to the machine, the horizontal air-pressure which is brought upon the slats becomes converted,

LOCOMOTIVE RETURNS FOR THE MONTH OF MARCH, 1893.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Locomotive Mileage. Freight Trains.	Locomotive Mileage. Service and Switching.	Locomotive Mileage. Total.	Locomotive Mileage. Average per Engine.	Av. Train. Passenger Cars.	Av. Train. Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Coal Burned per Mile. Freight Train Mile.	Coal Burned per Mile. Service and Switching Mile.	Coal Burned per Mile. Train Mile, all Service.	Coal Burned per Mile. Passenger Car Mile.	Coal Burned per Mile. Freight Car Mile.	Cost per Locomotive Mile. Repairs.	Cost per Locomotive Mile. Fuel.	Cost per Locomotive Mile. Oil, Tallow and Waste.	Cost per Locomotive Mile. Other Accounts.	Cost per Locomotive Mile. Engineers and Firemen.	Cost per Locomotive Mile. Wiping, etc.	Cost per Locomotive Mile. Total.	Cost per Car Mile. Passenger.	Cost per Car Mile. Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Alabama, Great Southern																									
Alabama & Vicksburg																									
Atchison, Topeka & Santa Fé	834				1,906,471	2,264,546	3,790						88.45			5.94	7.14	0.27	1.58	6.66	0.18	21.77			1.55
Canadian Pacific	618		409,278	908,938	324,074	1,632,290	2,664						77.86			4.59	12.76	0.39		5.76	1.49	24.99		2.20	3.28
Chic., Burlington & Quincy	549					1,847,001		4.90	17.71				91.49			5.68	6.64	0.25	0.34	6.49	0.09	19.49			1.44
Chic., Milwaukee & St. Paul	825					2,509,545	3,041						71.25			4.12	7.89	0.28		6.86		19.15			2.00
Chic., Rock Island & Pacific			573,052	917,251	446,611	1,936,914										3.03	6.67	0.27	3.03	5.97	4.20	16.36			
Chicago & Northwestern	888		709,964	1,470,673	680,993	2,861,630	3,222						93.62			4.09	8.40	0.37		6.40	0.90	20.16			1.77
Cincinnati Southern																									
Cumberland & Penn.*	22	22	5,571	35,721		41,292	1,876						91.18			7.27	4.96	0.39			1.87	14.49			
Delaware, Lackawanna & W. Main L.		190				669,340	3,522						68.77			3.37	6.88	0.39		5.89		16.53			
Morris & Essex Division	159		172,340	162,144	101,861	436,345	2,745						70.92			4.07	10.99	0.41		6.22		21.69			3.07
Hannibal & St. Joseph	76		73,461	176,092	41,271	290,770	3,983	5.22	16.14				86.91	16.30	6.70	5.05	6.29	0.11	0.37	6.66	0.08	18.51			1.40
Kansas City, F. S. & Memphis	150		101,399	280,384	119,193	500,976	3,339						69.17			3.92	5.83	0.28		7.49	0.37	17.89			1.65
Kan. City, Mem. & Birm	42	37	36,557	61,661	14,163	112,381	3,037						93.89			4.18	3.75	0.22	0.33	6.95		15.48			1.05
Kan. City, St. Jo. & Council Bluffs	38	34	59,644	47,143	41,374	148,161	4,064	5.05	21.12				67.66	14.25	4.69	4.43	6.36	0.15	0.49	5.86	0.08	17.32			1.98
Lake Shore & Mich. Southern	590		457,514	966,185	561,117	1,984,816	3,525						71.41			3.33	5.63		0.19	6.95	0.16	16.25			1.57
Louisville & Nashville		348	436,852	823,311	381,927	1,642,090	3,627	5.08	16.44	64.50	115.54	49.04	84.72	12.91	6.78	4.42	6.69	0.26	1.41	6.08	0.59	19.45	3.39	1.46	1.58
Manhattan Elevated		297	786,558		62,236	848,794	2,857						48.78			2.50	9.80	0.20		8.90		21.40			4.01
Mexican Central	148	114				400,890	3,516						71.76			5.17	14.54	0.48	0.18	5.18	0.81	26.36			4.80
Mil., L. S. & Western	112		79,298	139,176	80,082	298,556	2,665						80.97			3.13	11.27	0.21		6.31	0.96	21.88			2.80
Minn., St. Paul & Sault Ste. Marie			64,735	150,514	38,117	253,366		4.34	16.75				92.54			5.14	15.66	0.26		6.74		27.80		2.50	3.38
Missouri Pacific	339	303	1,453,927	9,382,962		1,117,942	3,656	4.35	16.16				88.16			6.22	6.19	0.31	1.38	6.47	1.56	22.13	4.41	1.68	1.37
Mobile & Ohio	107	89	74,903	149,640	62,318	286,861	3,223						67.61			2.96	4.80	0.22	0.62	5.75	0.98	15.35			1.43
N. O. and Northeastern																									
N. Y., Lake Erie & Western		611	463,388	957,410	286,257	1,707,055	2,619	4.50	21.40	83.60	141.80	85.65		20.60	6.60	5.38	8.55	0.38	2.00	7.41	1.15	24.87			1.46
N. Y., Pennsylvania & Ohio	257		136,545	475,885	153,088	765,518	2,978	5.50	17.70	68.90	122.80	70.20		12.50	6.90	4.43	5.72	0.30	2.78	6.84	1.01	21.08			1.12
Norfolk & Western, Gen. East. Div.‡			116,620	304,339	58,079	479,040	2,869	4.70	20.50	51.70	124.40			11.00	6.10	5.50	3.80	0.07				10.00			
General Western Division‡			108,600	316,486	44,890	469,976	2,889	5.46	16.82	73.00	141.00		125.00			7.59	4.52	0.63				12.74			
Ohio and Mississippi																									
Old Colony		242	345,924	143,753	241,075	630,742	2,606						65.19			3.32	12.22	0.62		6.73	0.81	23.70			3.75
Philadelphia & Reading			480,098	370,583	1,158,702	2,009,383							89.96			4.85	5.04	0.30		5.76	0.40	16.35			
Southern Pacific, Pacific System		719				1,708,627	2,376						68.74			6.27	17.79	0.21	2.24	7.31	1.22	35.04			5.28
Union Pacific	993		709,270	1,274,825	489,830	2,473,925	2,492	5.59	16.38	88.12	128.98		100.00	14.93	8.47	7.43	10.35	0.43	0.92	8.15	1.22	28.50	4.55	2.94	2.05
Vicksburg, S. & P.																									
Wabash	495	369	406,616	713,647	319,226	1,439,389	3,900	4.97	17.12	73.55	113.83	62.61	91.11	14.78	6.65	3.36	5.17	0.29		6.34	[illegible]	16.02	2.91	1.05	1.16
Wisconsin Central	153	120	127,625	263,570	73,337	464,532	3,871						94.65			2.94	11.34	0.27		7.14		21.69			2.37

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

‡ Wages of engineers and firemen not included in cost.

by reason of the form of the slats, into an upward vertical pressure which acts as a lifting power and raises the machine into the air.

There are 50 of these sustainers or slats, each 1½ in. wide and 22 ft. long. They are fitted 2 in. apart, and with their edges horizontal, in a frame 22 ft. wide and 9 ft. 6 in. high. These sustainers have a combined area of lifting surface of 136 sq. ft., and they are carried in their frame upon a carriage resembling a canoe 25 ft. long and 1 ft. 6 in. wide at the rear, but tapering to a point at the front. The frame of slats is fixed transversely to the length of the carriage, and in outline the whole resembles a small boat fitted with a large sail. As this machine is not yet allowed to soar away into space, but is earth-bound, it is mounted on a pair of 12-in. wheels at the rear and a guide wheel of the same diameter in front. Upon the carriage and near the sustainers, which are at the rear end, are placed the engine and boiler and the air-propeller. The engine is compound, having cylinders 1¾ in. and 3¾ in. in diameter respectively, with a 6-in. stroke, and fitted with ordinary slide valves. The boiler is a cylindrical vessel of phosphor bronze 12 in. in diameter and 16 in. long. It has 12 sq. ft. of heating surface, made up of Field tubes of ⅜ in. outside diameter and 14 in. long. The fire-grate area is 70 sq. in., and the fuel used is Welsh coal, the working pressure being 180 lbs. per sq. in. The propeller is two bladed, 6 ft. in diameter, and of 8 ft. pitch, and has 4 sq. ft. of blade surface. It is driven at the rate of about 400 revolutions per minute. The weights of the various parts of the machine are: Carriage and wheels, 60 lbs.; machinery, with water in boiler and fire on grate, 200 lbs.; sustainers, 70 lbs.; total weight of machine in working order, 330 lbs.

In order to test this machine a circular wood track 628 ft. in circumference has been laid down in the grounds of Messrs. Cogswell & Harrison's gun factory at Harrow. It was tethered by wires to a central post, the wheels being arranged so as to run in a circular path. Besides its own weight the machine carried 56 lbs. of shot and 16 lbs. of iron. The field in which the track is laid has a slight incline, and at the time of the trial a fresh wind was blowing. A number of runs were made, the result of which was, as regards horizontal motion, a speed of 28 miles an hour when the machine had got up speed and was well on its way. As regards vertical motion, with speed well on and facing the wind the rear end of the machine was lifted a *maximum* of about 3 ft. from the track, the lifting, to a greater or less height, continuing over about two-thirds of the course. The machine was then tethered from behind and the machinery started, when it was found to exert a dead pull of 75 lbs. As previously stated, the machine was held captive, there being insufficient room to experiment with it free, which also for other reasons is at present undesirable. Sufficient, however, has been done to demonstrate that it possesses a tendency to ascend, and, this having been ascertained, it remains for the principle to be applied to a machine which shall be capable of sustained aerial flight. And, to be a success, not only must it be capable of sustained flight, but it must be capable of correctly poising itself in the air during flight and during a gently inclined descent, should the propelling power by any accident become inoperative. This, it is claimed, the machine in question will do. Theoretically it should.

A late number of the *English Mechanic* reports that Mr. Phillips's flying machine is said to have soared "without touching," the speed being 40 miles an hour.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.*

The object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in May, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN APRIL.

Since our list of accidents which occurred in April was published, we have received information of the following which occurred in that month:

Waco, Tex., April 22.—C. M. Hilbert, fireman, and Ed Harding, engineer of Cotton Belt freights, were crushed in a railroad accident at this place. Hilbert is dead, and Harding not expected to live.

Port Byron, N. Y., April 23.—Edward Dougherty, of East Syracuse, a fireman on the Central Railroad, met a horrible death early yesterday morning. While his freight train stopped in the yard he went under the engine to take out the cinders. Unaware of his position, the engineer started up. Dougherty's body was frightfully mutilated. The train proceeded two miles before the accident was discovered. A following train completed the work of mutilation.

Somerset, Pa., April 25.—Five persons were killed, two fatally injured, and a number of others hurt in a runaway train accident on the Bare Rocks Railroad. The train, loaded with stone and carrying about 20 workmen besides the crew of the train and several passengers, while coming down the heavy grade became unmanageable, and crashed into a number of loaded cars standing on the track. The locomotive was completely demolished, and the cars piled on top of one another in a huge mass.

Of the injured, Neff, the engineer, is the most seriously hurt, being badly scalded and one of his arms broken. He will recover. His son was so badly scalded that he died a few hours after the accident.

Meyersdale, Pa., April 30.—Thomas Muldoon, fireman on engine 561, which was hauling one of the circus trains to Pittsburgh, Sunday, was severely injured at Garrett, while standing on a box car and coming in contact with the top of the bridge at that place.

ACCIDENTS IN MAY.

Sarnia, Ont., May 3.—Harry Ryan, an engineer on the Chicago & Grand Trunk, met with a peculiar and painful accident. He was running his engine against a strong head-wind between Lansing and Battle Creek. As the fireman opened the furnace doors the flames shot out. As the engineer's clothing was covered with oil it readily took fire, and Mr. Ryan was severely burned about the legs, body, arms, and hands before the flames could be extinguished. The wind was blowing a gale at the time.

New Brunswick, N. J., May 3.—Edward Wilson, a fireman in the employ of the Pennsylvania Railroad, while making some repairs to his engine at East New Brunswick on Wednesday night was struck by a passing train and had his skull fractured. His recovery is doubted.

Niagara Falls, May 6.—Two box cars loaded with sand on the Niagara Falls Park & River Railway broke loose on the Queenston Mountain Saturday evening and started down the swift incline. Patrick O'Neill, the fireman on the dummy engine used on the road, was on the cars. He attempted to stop the heavy cars by putting on the brakes. They failed to make any impression, and the man jumped when they were running at a 50-mile clip. He suffered severe bruises and a broken leg.

Port Huron, Mich., May 6.—George W. Rutherford, a Chicago & Grand Trunk engineer, was caught between two engines this forenoon and quite severely injured.

Lafayette, Ind., May 7.—On approaching this place on a descending grade, it is said that the air-brakes would not work, and the engineer called for brakes and whistled the danger signal, but the speed could not be checked, and the train shot down the grade and across the Wabash River at the rate of about 75 miles an hour.

There is a short curve where the track enters the Union depot, and at this point the train left the track, tearing through the depot, knocking down the iron sheds and smashing the express, two mail cars, and a combination car to splinters, and piling the rest of the train on top of them, the engine being buried out of sight.

Michael Walsh, engineer, and Sterling McInnis, fireman, and eight other persons were killed and 10 were injured. Engineer Walsh was seen by the fireman of a Big Four freight train that was lying on the west track near the depot as the

* In our report of accidents that occurred in February, which was published in April, was an account of the explosion of engine No. 108 of the Baltimore & Ohio Railroad at Norwood. An officer of that road requests us to say that they had no engine No. 108 at that time, there is no Norwood on their line, and they have not had an explosion for the last four years, and do not expect to have any. Our reports of the accidents which we publish are taken chiefly from the daily papers, and it is of course impossible for us to verify their correctness. We regret though that we did injustice to the Baltimore & Ohio road or any of its officers.

fated express dashed by. He was at the throttle, apparently reversing the engine. When the engine left the track it turned on its side, and Walsh jumped. He was caught by the front car and jammed into the works of the engine, which were still running. His body, which was mangled beyond recognition, was not rescued until late this afternoon. The body of McInnis was also terribly mutilated.

Not one of the passengers killed was aboard the train. They were waiting in the depot to board it, and, hearing the approach of the train, which could not be seen, stepped out of the waiting-room under the sheds and were caught, as was also Meyers, the hackman. John Lennon was sitting in his mail wagon, from which he could not escape, and was killed in his seat.

Columbia, Pa., May 7.—Charles Harner, an extra fireman on the Pennsylvania Railroad, when near Downingtown was sent out to flag approaching trains. When several hundred yards from his train he seated himself on the ties close to the rails, where he soon fell asleep. The noise of an approaching train failed to awaken him, and every attempt to hold the heavy train proved useless. In a few moments the engine was upon him, striking his back, hurling him a considerable distance. Harner was found lying along the track in an unconscious condition and bleeding profusely. He is not nearly as seriously injured as first thought.

Akron, O., May 8.—George Kiehl, a fireman on the Creston local on the Erie Railroad, was seriously injured and narrowly escaped death at Creston yesterday. The train was on the siding at Kent awaiting No. 4, the through express. As it dashed past Kiehl put himself partially out of the window, and was struck by the baggage car. He was almost drawn from the cab by the blow, but kept his place. His wrist was broken and he was otherwise injured.

Little Falls, Minn., May 11.—Thomas McGinnis, who runs the switch engine in the N. P. Railway yards, was run over by train No. 1 at Staples, and had both his legs crushed off. He was taken to a hospital at Brainerd, and was reported to be dying this morning.

Steubenville, O., May 12.—Frank Burns, a fireman on the Panhandle Railroad, was injured by his head coming in contact with some object while he was looking out of the cab window. It is said he would not recover.

Cairo, Ill., May 13.—The south-bound passenger train on the St. Louis & Southwestern Road was wrecked at 5 o'clock this evening 7 miles below Bird's Point, Mo. Engineer King, of Mt. Carmel, Ill , and Fireman Smith were instantly killed.

Reading, Pa., May 13.—Two persons were killed and several severely injured by the explosion of a locomotive on the Lebanon Valley branch of the Philadelphia & Reading Railroad at Lebanon this morning The killed are Levi Yocum, engineer, of this city, and John Yocum, of Lebanon, aged 14, a nephew of the engineer, who had got on the engine to see his uncle. George Sallada, conductor, of Reading, was fatally injured ; Grant Seiler, a boy, of Lebanon, who was riding on the engine, seriously hurt ; William Ansbach, crossing watchman, fatally injured. The latter's daughter Annie, aged 16, who had just brought her father's dinner, was also seriously and perhaps fatally injured. Isaac Beard, of this city, front brakeman, was severely injured. Several persons living half a block from the scene of the explosion were slightly injured. Their names have not been learned. The locomotive is a complete wreck. Several of the victims were blown half a square away.

Oakland, Cal., May 13.—In a collision at this place Engineer Kimball had his ankle badly injured.

Mascoutah, Ill., May 15.—A west-bound train on the Louisville & St. Louis Air Line Road ran into an open switch near West Belleville last night.

Fireman John Menker and a brakeman were killed outright. Engineer Mahaffey sustained injuries that will likely prove fatal. The engineer saw the open switch too late. He reversed his engine and jumped, but was caught under a carload of ties.

Anaconda, Mont., May 15.—Engineer George Eldredge and Brakeman James Morrison were severely injured in a wreck by which Fireman Stroub lost his life.

Lynchburg, Va., May 16.—It is reported that a head-on collision occurred at Six Mile Bridge last night on the Norfolk & Western Railroad, in which both engineers and firemen were badly injured.

Meadville, May 16.—Train No. 3 on the New York, Pennsylvania & Ohio Railroad ran into a landslide near Venango, 8 miles north of Meadville. Engineer Orrin Luke was fatally injured and the passengers badly shaken up, but none seriously hurt.

Hamburg, Pa., May 17.—A freight wreck occurred on the Reading Railroad at the sharp curve a short distance south of this station. A north-bound freight train ran into the rear end of a coal train, piling up a number of cars and wrecking them badly. Engineer Frank Fry, of Philadelphia, of the freight train, was injured.

Bradford, Pa., May 17.—While coming down a steep grade at Big Shanty a Buffalo, Rochester & Pittsburg coal train dashed into a work train standing on a cut. Falicia, foreman of the construction gang, was killed and two other Italians injured, one of them fatally. Engineer McClary of the work train jumped and sustained a broken shoulder.

Bradford, Pa., May 17.—A. P. Rogers, an engineer who had secured a position with the Buffalo, Rochester & Pittsburgh Company, was taking a trip with Engineer Breese to learn the road. When coming down the grade this side of East Concord the long train was hard to control, and as the air-brakes did not work well, they were not used. The engine had to hold the cars in check. While this was being done the pin in the coupling attaching the train to the locomotive jumped out, and the detached engine bounded ahead of the train. The locomotive was soon slacked up, and when the cars behind struck against it, Mr. Rogers was hurled out of the engine cab and down an embankment. He struck on one of the timbers at the approach to the Cattaraugus viaduct, and was badly hurt about the head and body. A deep gash was cut under his jaw, and he was severely stunned.

Canton, O., May 19.—As Engineer Al Worthen, Fireman Frank Turner, and Conductor Ed Smith were coming from Navarre on the W. & L. E. Railroad with engine No. 37 and a caboose, at a point about one mile south of the station, near the Runser Farm, the train was passing over a bridge at that point on a side track, when suddenly the bridge, track, abutments, engine, caboose, crew and all passed down into the river. None were hurt except the engineer, whose injury is of a trifling nature, he having only sprained his back, but all were given a cooling bath and had to swim out. The wreck was caused by the water weakening the abutments.

Albany, May 19.—A collision between a gravel train and a west-bound fast freight occurred at Little Falls this forenoon on the New York Central Road. The gravel engine was derailed and 12 cars of the fast freight demolished. Tracks 1, 2 and 3 were blocked. Engineer O'Hara of the gravel train was seriously hurt.

New York, May 20.—Henry Hammond, aged 23, an engineer, residing at 157 East Thirty-ninth Street, last evening, in attempting to jump on board a moving train at Sherman Park, was thrown under the wheels. Both legs were cut off below the knees. He was taken to the Grand Central station, and from there to Bellevue Hospital. He will die.

Lancaster, Pa., May 20.—A broken truck of a freight car wrecked several cars on the Pennsylvania Railroad, near Thorndale. An east-bound train ran into them, and 20 cars in all were wrecked. Engineer C. W. Mann and Fireman John McCann, of Harrisburg, were badly injured, the former dying this afternoon. The fireman is in a serious condition.

Thorndale, Pa., May 20.—While pulling a freight train out of a siding another train crashed into its side on the Pennsylvania Railroad, wrecking the engine and 24 cars and terribly scalding Mann, the engineer, and his fireman. As quickly as possible they were extricated from the wrecked engine and taken to the Presbyterian Hospital in Harrisburg, where at 10.30 yesterday morning Mann died.

Wilkesbarre, Pa., May 22.—George Dotter, a fireman on engine 650, met with an accident at Pittston Junction that will in all probability prove fatal. He was hanging out the cab window when his engine crashed into a freight car that was not pushed in far enough off the main line. He was thrown from the cab to the track.

Waycross, Ga., May 23.—As the passenger train on the Waycross Air Line Railroad reached Kettle Creek trestle, the engine jumped down the embankment followed by the train of loaded cars, and the train was almost a total wreck. The engineer and fireman escaped with a few bruises.

Fort Madison, Iowa, May 24.—A wreck occurred on the Atchison, Topeka & Santa Fé Road, about 20 miles west of New Boston, at 12.30 P.M., when a freight engine crashed into the California express, west-bound, badly crippling both engines. Fireman Sieptuns, of the passenger, was scalded to death by escaping steam, and the engineer, Andrew Smith, dangerously hurt.

Austin, Tex., May 28.—In a collision on the suburban railroad to the dam near this city two persons were killed and 10 were injured. The dead are : Charles Link, fireman ; Francisco Salio, passenger. All the injured were terribly cut. The collision was caused by the incoming train neglecting to obey orders to take a side-track to allow the other train to pass.

Shelbyville, Ind., May 28.—A passenger train was derailed

by a blind horse, which wandered on the track and was struck by the engine.

As the engine went over, Fireman Williams was thrown from the cab over a barbed-wire fence at least 15 ft. away. Engineer Plant was buried in the wrecked cab. He was not pinned down, but was doubled up in a small space, with one hand on the throttle and the other on the reverse lever. He was literally cooked by the steam, great strips of flesh peeling from him.

As soon as he could get on his feet Fireman Williams ran to the locomotive and assisted in taking out his engineer. The unfortunate man was conscious, and said: "Oh, what will my wife do when she hears this—it will kill her."

He died soon after. Fireman Williams was hurt about the back, but his injuries are not thought to be fatal.

Quanah, Tex., May 30.—Passenger train No. 2 was derailed 6 miles north of Quanah by striking a cow on the track, killing the fireman outright and badly injuring Engineer Samuels.

Avoca, N. Y., May 30.—Engineer William Masters, of Erie freight train No. 134, was at the station, and after receiving orders, directed his fireman to pull out. He then boarded the rear end of the train, and while walking over the cars slipped and fell to the ground. He lay there stunned until found a little later by the crew of an extra west-bound freight. He was badly shaken up, but it is thought will recover.

Canton, O., May 30.—As engine No. 20 of the Valley Railroad was pulling an excursion train, and when near East Akron, the right side-rod broke near the middle, badly wrecking the cab and tearing the running board brackets off, thereby allowing steam and water to escape. The engineer was pretty badly shaken up, but not seriously injured. The fireman reached over and applied the airbrake with his foot. The rod was of the strap pattern.

Lebanon, N. H., May 31.—The Montreal daily express left the rails just below Roxbury, Vt. A misplaced switch was the cause, and the locomotive went down an embankment, carrying with it the baggage and mail cars, and the forward end of the first passenger coach. The fireman, seeing his immediate danger, jumped, landing in the mud, while the brave engineer, O. R. Kirk, of St. Albans, held his post. The escaping steam for a few moments made a search impossible, but later Engineer Kirk was extricated from his perilous position. Mr. Kirk was pinned down in the cab against the firebox by the reverse lever, and could not be liberated for over three hours. His legs were broken and he was frightfully burned, but he stood the terrible ordeal without a murmur, and died about 8 o'clock this forenoon.

Parkersburg, W. Va., May 31.—A head-end collision between an engine and a freight train occurred near Little Hocking on the Baltimore & Ohio Southwestern. Engineer Ball jumped and was thrown into a ditch and had a leg broken. His fireman was pinned in the cab, but escaped with only slight injuries. Engineer Shafer also jumped before the trains came together and escaped without injury, but his fireman, Mike O'Brien, was caught between the rear of the boiler and the top of the cab and was nearly cooked by the escaping steam, and is fatally hurt.

Chattanooga, May 31.—There was a head-end collision between freight trains on the Cincinnati Southern near Rathburn, Tenn., owing to a mistake in orders. Fireman McClellan was seriously injured and both engines and 10 cars totally wrecked.

Our report for May, it will be seen, includes 35 accidents, in which 10 engineers and 10 firemen were killed, and 17 engineers and 11 firemen were injured. The causes of the accidents may be classed as follows:

Boiler explosions	1
Broken coupling-rod	1
Derailments	6
Collisions	8
Falling from train	2
Failure of bridge	1
"Wrecked"	3
Runaway trains	3
Struck by train	3
Struck by other objects	1
Gas explosion from furnace door	1
Run over	2
Open switch	1
Landslide	1
Broken truck	1
	35

PROCEEDINGS OF SOCIETIES.

Boston Society of Civil Engineers.—At the meeting held on May 17 Mr. Dexter Brackett gave an account of the freezing of the main supplying water to Long Island, in Boston Harbor. About 1,200 ft. of 6-in. pipe laid with the Ward flexible joint across a channel between Moon and Long Islands was frozen during the past winter. The pipe, where frozen, was constantly covered with from 15 to 25 ft. of water, and the freezing was due to the fact that the salt water of the harbor, by which the 6-in. pipe was surrounded, was cooled to the temperature of 28° F. Many of the pipes, instead of being burst by the freezing water, were separated at the joints—that is, the spigot ends of the pipes were drawn entirely out of the bells into which they had been leaded.

Engineers' Club of Philadelphia.—At the meeting of the Club, held on June 3, a number of technical questions were brought up for discussion. Among them was that of the Load for Ball Bearings. Mr. Wilfred Lewis opened the discussion, and explained that the question was intended to cover roller bearings as well as ball bearings, and that, in view of the large and increasing demand for these bearings, it was remarkable how little definite information could be obtained concerning them.

Some time ago he wrote to a prominent manufacturer of ball bearings for such data as could be given in regard to the carrying capacity of hardened steel balls between plates of the same material, and in reply he was informed that almost nothing was positively known. Some crude experiments had been made upon ½-in. balls, which showed them to have an ultimate strength of 2,000 lbs., and a safe working limit of 400 lbs.; but for car journals, in which the motion was continuous and rapid, 200 lbs. per ball was recommended as preferable. Whether a ½-in. ball would carry twice as much or four times as much as a ½-in. ball could not be stated, but the impression seemed to be that, over a given extent of surface, more load could be carried on small balls than on large ones. The effect of hardening was believed to increase tenfold the carrying capacity of a ball bearing.

In regard to roller bearings, but one formula is known to be in common use. This makes the load carried by any given roll proportional to the square root of its diameter, and the general adoption of this formula may be credited to the authority of the late C. Shaler Smith, while the investigation upon which it is based is said to be due to Professor Grashof.

The Engineering Association of the South.—At the regular meeting of the Engineering Association of the South, Nashville, Tenn., June 8, 1893, a paper on the Pecos Viaduct was presented by Mr. J. Kruttschnitt. In the original construction of the Galveston, Harrisburg & San Antonio Railroad (Southern Pacific), the deep cañon of the Pecos River presented such difficulties that, to avoid it, a considerable *détour* was made and the line built with heavy curvature and grades, yet at great expense; besides, operating expenses were large, and the unstable nature of the rock made necessary constant patrol of the track and reduction of train speed. These difficulties led to the location of a cut-off, crossing the Pecos River on the viaduct described.

The two lines are thus compared:

	Operated Line.	Cut-off.
Actual length in miles	34.5	13 3
Comparative length reduced to level tangents	38 77	17.9
Number of feet wooden trestles	3,600	600
" " iron bridging	2,780	2,180
Weight of iron bridging in pounds	3,893,000	3,640,000
Number of degrees of curvature	2,926.6	901.7
Maximum degree of curvature	10	5
" grade in feet per mile	58.8	52.8
Feet rise and fall	902.27	594.38

The masonry piers and footings are of tough limestone laid in Portland cement mortar, and were built between March and November, 1891, 3,270 cubic yards costing $70,000.

For comparison, the lengths, heights and weights of the six highest viaducts in the world are given:

Name.	Length between abutments.	[redacted] rail to water level.	Weight in pounds.	Weight per sq. ft. vertical projection.	Live load per lineal foot.
Garabit	1,813.00	[redacted]	7,040,000	22.74	3,290 lbs.
Loa	800.00	[redacted]	2,497,600	20.00	2,800 "
Pecos	2,180.50	[redacted]	3,640,000	13.33	5,000 and 30,000 concentrated.
Malleco	1,139.80	[redacted]	3,148,886	15.50	2,750 lbs.
Kinzua	2,044.00	301.10	3,500,000	9.10	....
Evaux	812.20	[redacted]	[redacted]	19.17	....

This table shows that the Pecos ranks one of the highest viaducts in the world, also that it leads in live load specifications and lightness. One of the most remarkable features in the work was the traveler used in erecting, with its overhang,

perhaps unequaled, of 124.5 ft., which was secured by a 57-ft. wheel base, the traveler being counterbalanced and clamped to the completed parts of the structure. The iron was brought out on push cars on the permanent track, taken by the crab on the traveler, lowered and held in position till the connections were made. The heaviest pieces weighed 11 tons. After erecting the east half of the structure, the traveler was taken to pieces and shipped by the operated line to the west half, a lighter traveler meanwhile raising the short towers at the west end. In erecting the east half 41,000 lbs. iron was averaged per day net time, and 62,000 lbs. in the west half. The average number of men employed in erecting was 67; and 87 working days were consumed from beginning erection to connecting the suspended span. The superstructure was built by the Phœnix Bridge Company. The floor timbers are covered by galvanized iron for fire protection. The total cost was $250,000.

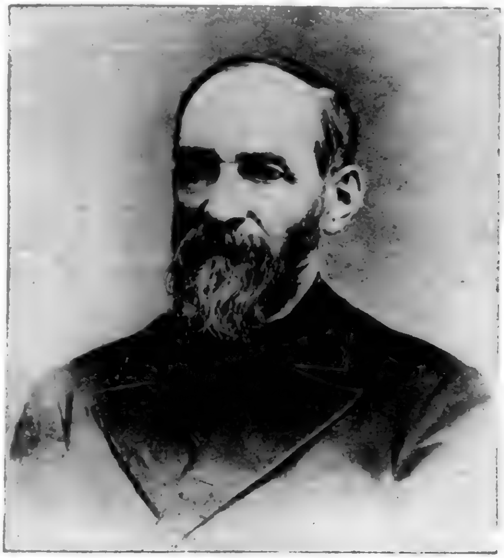
The paper was fully illustrated by drawings and photographs.

The next meeting of the Association will be held in Nashville, July 13, 1893.

OBITUARIES.

Walter McQueen.

The death of Walter McQueen, which occurred at his home in Schenectady, N. Y., on June 16, has removed the last of the early generation of locomotive builders in this country. Among them were Matthias W. Baldwin, William and Septimus Norris, of Philadelphia; Thomas Rogers, William S. Hudson and the two Cookes, of Paterson, N. J.; Ross Winans, of Baltimore; Holmes Hinkley, of Boston; William Mason and Mr. Fairbanks, of Taunton, Mass. The histories of these remarkable men have never been adequately written.



WALTER McQUEEN.

Mr. McQueen was born in Sterlingshire, Scotland, on October 8, 1817, and was, therefore, in his 76th year. He was the next to the youngest of eight children—five sisters and two brothers. In 1830 his parents emigrated to this country and located at Perth, in Fulton County, N. Y. Mr. McQueen's first employment in machine business was as a feeder of a horseshoe machine in the Burden Iron Works, in Troy, N. Y. This was about the year 1835. Later he began an apprenticeship with William B. Many, of Albany, who carried on a general machine business and manufactured steam engines and did mill work. In 1838, after having completed his term of service there, Mr. McQueen erected the first stationary engine put up in Gloversville for the glove trade. In this same year Mr. McQueen went with Eaton & Gilbert, of Troy, the original firm of the present Gilbert Car Company. Their works at that time were on the site of the present Union Railroad Station, in Troy.

In 1839 Mr. McQueen made a visit to his old home in Scotland, and remained there for some time in the shops of the Messrs. Napier, in Glasgow, and while there worked on the first Cunard steamship which was built by this firm.

In the fall of the same year he returned to this country and secured employment with the Hudson & Berkshire Railroad, at Hudson, N. Y., of which Mr. Waterman was then Master Mechanic. He remained there until 1843, when he went to Schenectady, and was employed by the Utica & Schenectady Railroad Company. Two years later he went to Albany as Master Mechanic of the Mohawk & Hudson Road, which had been reorganized as the Albany & Schenectady Road.

During the four years he remained in this position Mr. McQueen built five locomotives for the road, and also rebuilt one which came from England in 1831. He also built at this time an engine with a 15 × 22-in. cylinder, which was named the *Mohawk*. In 1848 the *Mohawk* established a reputation for itself and for its builder by beating a Norris (Philadelphia) locomotive in a trial haul of cars up the grade at Schenectady. The Norris was a much larger locomotive than the *Mohawk*, and hauled only 16 cars to the *Mohawk's* 26.

About the same time he also built an engine with a single pair of driving-wheels and a pair of small trailing wheels behind, and having 12 × 18 in. cylinders and 4½ ft. wheels. This engine had a transverse spring over the trailing axle which extended from one driving-box to the other. By means of a screw on the foot-board this spring could be compressed or relaxed so as to throw more or less weight on the trailing wheels. In starting, the weight would be taken off of these wheels, thus increasing the load on the driving-wheels. After the train was started the spring was screwed up, and some of the load was then taken off of the drivers. This, perhaps, was one of the earliest "traction increasers," a favorite idea with inventors ever since. The engine referred to, with one car attached, carried the governor's message from Albany to Schenectady in 24 minutes, or the exact schedule time of the Empire Express of to-day.

In 1848 Mr. McQueen left Albany for New York to accept the position of Master Mechanic of the Hudson River Railroad, which was then being constructed from New York to Peekskill. He built the old shops at Thirtieth Street near the East River. The road was not completed to Albany until 1851.

In 1852 Mr. McQueen left the Hudson River Railroad to accept the place of Superintendent of the Schenectady Locomotive Works. While occupying that position this company built 1,000 locomotives of different designs. He was the originator of a number of marked improvements in locomotive construction, and the McQueen locomotive acquired a distinctive reputation the whole country over, and has been the subject of many harangues in innumerable engine houses and while trains were quietly waiting on side tracks. In 1847 he applied air and vacuum chambers on locomotive pumps, to lessen the shocks and concussions due to the rapid working of the plungers. This improvement was afterward universally adopted until injectors displaced pumps. He was also the first to use a cast-iron cylinder saddle attached to a cylindrical smoke-box. With the modification that half of this saddle is now cast on each cylinder, this improvement has also come into general use.

In 1876 he resigned the position of Superintendent of the works and was elected Vice-President. Since then he had practically retired from the business. In all his dealings during his long business career the deceased followed a course of the strictest integrity, and commanded the esteem and respect of all with whom he came in contact. By adhering to pure business principles, utilizing his natural talents and putting his acquired abilities to such uses that they became of benefit to mankind, he rose from comparative obscurity to a position of importance and wealth.

Walter McQueen was married in 1842 to Charlotte Augusta Cole, who died in 1879. The deceased is survived by five children—Hon. D. P. McQueen, Mrs. Joshua Barker, and Mr. Henry B. McQueen, of Schenectady; Mrs. F. A. Beckwith, of Cleveland, O., and Mr. Robert F. McQueen, of New York.

For most of the particulars of Mr. McQueen's life we are indebted to the daily papers of Schenectady.

P. J. Flynn.

P. J. Flynn, the civil engineer, died at Los Angeles, Cal., June 1, after a short illness, of congestion of the brain. Mr. Flynn was a recognized authority on hydraulic engineering, and was for a number of years in the service of the British Government in India, employed on some of the most important engineering works in the empire, and was also engaged in extensive irrigating works on this continent. He was the author of several standard text-books on engineering, which are accepted by the profession throughout the world. He only published his last work a few months ago, which met with a ready sale, he having received a large order from London and also several from India, and would, in a short time, have been independent from the royalties. Mr. Flynn was a native of Ireland, and was 55 years of age at the time of his death. He leaves no family.—*Los Angeles Times.*

HOURS OF LABOR ON BRITISH RAILWAYS.

At a recent hearing at the British Board of Trade a deputation of signalmen was heard who urged that the Railway Servants (Hours of Labor) Bill should be amended by the insertion of a *maximum* with regard to the hours of labor of signalmen.

Mr. Mundella, in reply, said that any excessive hours of labor imposed upon signalmen would be of the utmost danger to the public; but the bill applied to all railway servants, from the station-masters downward—400,000 men; and it must therefore be elastic. He had brought in a bill stronger than any other which had been introduced on the subject, which not only gave powers to, but imposed duties upon the Board of Trade. If it appeared to the Board that there was in the case of any railway company reasonable ground of complaint with respect to the hours of labor of any class of railway servants, the Board was required to order the company within a specified time to submit such a schedule "as will in the opinion of the Board bring the actual hours of work within reasonable limits." If the company failed to do that they could be brought before the Railway and Canal Commissioners, and if they failed to comply with any order made by the Commission they were liable to a fine of £100 a day. He asked the signalmen to wait and try the act.

In discussing the subject, Sir J. Gorst said the State had a right to interfere with the hours of labor of railway servants, because they were the servants of the public. The State had a right to see that persons so employed were not unreasonably worked, and the State had a right to interfere with the hours of labor of railway servants for the purpose of protecting the traveling public against the risk of accidents.

THE COLUMBIAN EXHIBITION.

Writing a letter or an article on the Great Fair is attended with somewhat the same difficulties that would be encountered in preparing an essay on, say, the universe. It is difficult to know where to begin or what to say first. One of the recent aphoristic fads about art is that artists should paint, not what they see, but what they remember. According to this hypothesis, the impression produced on the painter should be represented on canvas, and not the scene as it is and as it appears. If this theory were adopted in writing about the Exhibition, it might be said in Japanese or Chinese English, *big;* MUCH BIG; *white;* MUCH WHITE; as the foreign correspondents delight in saying our great show is an apotheosis of bigness. Everything—the grounds, the buildings, the locomotives, the cheeses and Lake Michigan—are all bigger than they were at any other exhibition ever held.

Perhaps no better idea can be given of the scale of the Exhibition than to quote a description from a recent number of the London *Times*, an authority certainly not prejudiced in favor of American achievements. We quote this description, as it is a very good one, and because there can be no suspicion that the American eagle has been allowed to influence its data. In the description referred to it is said:

"Briefly stated, the World's Fair is a vast aggregation of buildings and ornamental grounds covering a park of 586 acres on the southwestern shore of Lake Michigan, about 6 miles south of the center of Chicago. It has a coast line of a mile and a half fronting the lake, with the buildings spread along this entire distance, and also upon interior lagoons which have been dredged in the park to add to the attractions. Out in front a long wooden pier of 2,500 ft. is built into the lake to make a steamboat landing. A broad basin, dredged inland behind the pier, opens into the series of lagoons which extend a mile to the northward. The great buildings surround the basin and a spacious plaza to the westward, and also front upon the lagoons, the magnificent high-domed Administration Building standing in the center of the plaza. This grouping makes a most impressive array of colossal buildings. To the northward of the lagoons are numerous buildings representing foreign nations and the States of the American Union, each emblematic of its nationality, and out in front of these, on the lake shore, two-thirds of a mile above the long pier, is the British Victoria House, in a conspicuous position, having the huge reproduction of an American naval battleship alongside it, behind a protecting breakwater. . . .

"There are over 150 buildings of all kinds on the grounds, and all the greater buildings were long since finished, although final touches of painting and decoration are still being given to some of them. They are by far the finest collection of structures ever built for a World's Fair, and include some of the grandest ever erected. The larger structures, which if all united in one building would cover 130 acres, are the following, their dimensions being given in feet, with the floor and gallery space for exhibitors estimated in acres, and the cost of each:

Buildings.	Dimensions.	Space, Acres.	Cost.
Administration	[illegible]	4.5	£92,643
Manufactures	1,687 × 787	44	345,466
Machinery	842 × 494	17	234,779
" Annex	551 × 490	6.2	
" Boiler-house	1,103 × 86	2.2	
Agriculture	800 × 500	15	131,737
" Annex	550 × 312	4	
Electricity	690 × 345	9.3	84,670
Mining	700 × 350	8.5	53,306
Transportation	[illegible]	9.4	96,636
" Annex	850 × 435	8.5	
Horticultural	998 × 251	8	[illegible]
Fisheries	361 × 162	1.4	43,584
" Two Annexes	135 diameter.	.7	
Fine Arts	[illegible]	4.6	147,562
" Two Annexes	220 × 136	1.4	
Women's	[illegible]	3.3	27,060
United States	421 × 351	5.5	80,000
" Battleship	348 × 69	6	20,000
Illinois	450 × 160	5	[illegible]
Forestry	[illegible]	2.6	10,404
Railway Station	300 × 150	4	45,077
" Train shed	672 × 150		
Dairy	200 × 94	.8	5,862
Leather	625 × 150	4.3	17,886
Live-stock	[illegible]	2.5	12,458
Saw mill	[illegible]	1	[illegible]
Music-hall	246 × 140	.7	73,251
Casino	246 × 140	.7	
Peristyle	600 × 60	.9	
Pier and breakwater	2,500 × 250	11.5	64,313
*Art Institute (in Chicago)	.....	....	[illegible]
Choral hall	.....	....	17,349
Anthropological	.....	....	17,133
Service offices, etc	.....	....	42,057
Children's	.....	....	4,443
Monastery La Rabita	.....	....	5,861
Packing-case storehouse	.....	....	7,173
Total	.....	....	£1,840,785

"Besides stating these figures, I will also quote the following, showing some of the chief items of expenditure outside of the buildings:

Pumping works for water supply	£47,347
Constructing lagoons and harbor	157,560
" roads and walks	66,[illegible]
" bridges	17,178
" railways	65,915
" fire and police stations, etc	54,436
Grand fountains	24,[illegible]
Water pipe and sewerage	92,121
Statues and sculpture	34,[illegible]
Electric plant	148,[illegible]
Boilers and machinery	72,758
Decoration and coloring	31,643
Colonnade and obelisk	19,789
Architects' expenses	24,810
Dedication ceremonies	44,232
Salaries of officials and clerks	105,139
Publicity and promotion	32,762
Total	£1,061,463

"Such is the scale, material and financial, of this enormous show. It would be too much to say that all is finished, even now, but there is enough now on the square mile of surface of Jackson Park to occupy weeks in thoroughly seeing, and any visitor who pays his 2s. admission fee can now spend the day in examining an exhibition which beats in bigness anything ever attempted in this line outside of Chicago."

The most decided impression which probably most people will take away with them, after trying to see what is spread

* Intended for public meetings in connection with the Fair.

before the public in Jackson Park, is that they have had one of the biggest "tireds" that they have ever experienced.

Few people realize the limitations of their own capacity for seeing things. During the Centennial Exhibition, in Philadelphia, it was often amusing to see people who came there with excursion parties, and with only one day to see all that was to be seen. In the morning, when they first entered the grounds, the slightest event or object would attract their attention. About four o'clock in the afternoon they could be seen walking down the middle aisle of the great building, with their eyes fixed with a stony stare into space, utterly incapable of looking or seeing anything more. Their curiosity was completely satiated, and the limits of their capacities of observation had been exceeded. The same scenes are reenacted daily at Chicago, with the superadded fact, which has not received the condemnation which it deserves, that the management has not provided seats, or had not when our observations were made, at all adequate to the wants of visitors. It was painful to see frail women and fat men, and other human beings in all conditions of exhaustion and fatigue, seeking vainly for some place to sit down. This neglect is cruel, inhuman and brutal, and the reason assigned for it was more so, and was that certain concessions had been given on the roofs of the buildings and elsewhere, and one of the privileges going with them was the providing of seats, and that it would take away some of the profits of those holding the concessions if visitors were provided with facilities for sitting down elsewhere. This want of seats detracted very much from the pleasure and added greatly to the discomfort of visits to the grounds, and it was reported that a physician remarked that the management must either provide more seats or enlarge the hospital accommodation in the Park.

Railroad men and engineers will naturally be attracted most to the Transportation Building and to the Machinery Hall, and what will appeal most to their imaginations in each place will be, the locomotives in the one and the stationary engines in the other.

Altogether there are more than 50 modern locomotives—not including the ancient relics—on exhibition. In order to correspond with the predominant idea of the Fair, they are nearly all big locomotives, and the question of a lady who came to the writer while he was making notes and asked if he would not please tell her "Why they made them so big," was perhaps not so foolish as it seemed. At any rate, it was very hard to answer.

Modern American practice is very well represented. About all the types of locomotives and details of construction which are now current are shown. All the principal kinds of compound engines are shown, and some comments thereon will be found on our editorial page. There are Belpaire fire-boxes, radial stays and old-fashioned crown-bars. There is not a modern locomotive, however, in the American exhibit which has any other form of valve-gear excepting the link-motion. Among the French and English exhibits there are a number of different types of valve-gear; one—a French or Belgian engine—which looks like a mechanical nightmare. With the exception of the Shay-geared locomotive, exhibited by the Lima Locomotive and Machine Company, all the modern American engines seem to be characterized by great conservatism in design, whereas some of the foreign engines are fearfully and wonderfully made. There is no striking novelty among the American engines, although there are many details which are interesting.

Every draftsman should see and study a series of drawings of locomotives in the French Department. They are works of art. It is doubtful whether it would be possible to have any such work done in this country—that is, whether a draftsman could be found who is artist enough to do it.

The exhibit of the Baltimore & Ohio Railroad has already been described in these pages—that is, an account has been given of what was intended to be exhibited. At the time we last saw it, it was still incomplete. The old locomotive and models of others were all in place, but the pictures—photographs, paintings and drawings—of which there are about 1,700, were not all in place. A great deal of time could be spent in examining these. There has never been brought together so much material from which a history of the locomotive could be made, and it is to be hoped that when the Exhibition is ended that this unique collection may be preserved. There is besides these the much-written-about *John Bull* and the rebuilt *De Witt Clinton*; and one of the most frequent questions which was asked in the Locomotive Department by women and boys was, to be directed to "the first locomotive that ever run." It was not always certain whether they meant the *John Bull* or the *De Witt Clinton* or some other engine, and they always seemed to be disappointed on being told that neither of them was the "first locomotive that ever run" either in this country or in any other.

In a publication like this anything like a full description of the exhibits is impossible. A mere catalogue or enumeration of the exhibitors and the objects exhibited would occupy more space than we could possibly give to it. All that we can do, and all that will be attempted, will be to make notes of features which are more than usually interesting, and even in doing that we will not undertake to make any strict classification of the relative interestingness of different objects.

As a counterpart of the Baltimore & Ohio historical exhibit of locomotives, that in the German Department, showing the evolution of rails and track, is very interesting. It begins at the very beginning of railroads, when the old tram rails were used, and shows each successive step of development, including the great variety of different rails which have been laid at various periods, stone-block, wood, cast iron and steel sleepers. A short section of each kind of track is put down with sleepers, ballast and rails all complete.

A great variety of cars are also on exhibition. The Pullman and the Wagner companies have each a train consisting of cars of the various kinds provided by them. The magnificence and luxury of these makes it difficult to find adjectives which will do justice to them. The Canadian Pacific and the London & Northwestern roads also each have a train of the different kinds of passenger cars used on their lines. Besides these there are other cars for passenger and freight, for horse, steam and electric roads, the mere enumeration of which would occupy several pages of our paper.

Leaving the complete cars and locomotives and coming to their details, we find extensive exhibits of such things as car brakes and signals in great variety. Nearly every railroad man will be surprised to see so many different kinds of air-brakes exhibited. He who tries to understand the different systems of signals which are exhibited will find that it will require an amount of study almost as great as would be needed to be admitted to the bar, if he is not already a lawyer. Tired men and women gaze longingly on exhibits of car-seats, which display their potential comforts in the most exasperating way. Whether at the same time they anathematize the administration for not supplying seats in other places is not known, but if they are not members of church it would seem to be their duty to do so.

It may be added that the Exhibition is the despair of editors of technical papers. Some of them are like the man who was recently asked what he thought of the financial situation, and who answered that he had been trying with all his might to think something and couldn't—he could only feel—feel that he was dreadfully hard up. It is so with some of "us." Before going to Chicago "we" were intent on some systematic scheme for describing or discoursing on the Exhibition. It may be frankly confessed that we now have no such scheme; as none which we could devise was at all commensurate with the magnitude of the Great Fair, we have been compelled, like our financial friend, to confess our inability to think anything adequate to the occasion, and now we only *feel* that the Exhibition is greater than our capacity for describing it, and that THE AMERICAN ENGINEER AND RAILROAD JOURNAL is very "hard up" for space in its pages, which are too few and too small to describe all or even a small part of the interesting things which may be seen in Jackson Park.

NOTES AND NEWS.

European Coal Fields.—A Prussian mining expert has made investigations of the coal strata of the world, and expresses the belief that the coal deposits of Austria-Hungary, France, and Belgium will be exhausted in five centuries at most. Those of Great Britain and Russia will follow, and last of all the German strata will give out. The American coal deposits, he estimates, will not last longer than those of Europe.

Panhandled Trestle.—The panhandled trestle and bridge over the Tuscarawas River, west of New Comerstown, O., has been completed. The entire bridge is 450 ft. long, each truss being 153 ft. Owing to the location, the high water and the nature of the ground, the work of building the temporary trestle was attended with a great deal of danger. The trestle is in the shape of a "run around" and is over 600 ft. long.

A Novel Street Railway.—Ontario, Cal., has a street railway that is operated partly by horse-power and partly by gravity. When the town was founded an avenue 200 ft. wide was laid out with a space in the center for a street car line. This avenue is 6 miles long, running from the town of Ontario to the mountains, with a steady ascent varying from 100 to 250 ft. to the mile. In December, 1888, the railroad was com-

pleted and horse-cars put on. A couple of ingenious mechanics, J. B. Tays and James Birch, decided that the horses might as well ride on the down trip, and accordingly designed a small platform-car, which slides under the main car, for the descent. On this the horses ride down, the car running by gravity. The arrangement has been in successful use since March, 1889. The down trip is regularly made in 30 minutes, but the cars sometimes come down in half that time without stops. The horses or mules take very kindly to the arrangement.

The Electric Stop.—Those who are in a position to judge of its merits are emphatic in their endorsement of the new electric stop motion which is now being applied to spinning machinery, covering automatically, as it does, the unguarded places in the machinery. In the arrangement of this mechanism the two rolls between which the yarn passes are each connected with a pole of a battery; when the yarn breaks, the rolls immediately come in contact with each other, thus closing the circuit and actuating an electro-magnet, which stops the machinery instantly. In case the yarn, instead of passing on, becomes wrapped around the rolls, the increased thickness of the material forces the upper roll against a pin also connected with the battery, and the machinery is stopped as before.

A Curious Clock.—A curious clock, destined for the World's Fair at Chicago, has been made by a clockmaker at Warsaw named Goldfaden, who has worked at it six years. The clock represents a railway station, with waiting-rooms for the traveler, telegraph and ticket offices, a very pretty, well-lighted platform, and a flower garden, in the center of which is a sparkling fountain of clear water. Past the railway station run the lines. There are also signal-boxes, signals, lights and reservoirs—in fact, everything that belongs to a railway station to the smallest detail. In the cupola of the central tower is a clock which shows the time of the place. Every quarter of an hour the station begins to show signs of life. First of all the telegraph official begins to work. A long line of people form at the ticket office to buy tickets; porters carry luggage; the bell is rung, and out of the tunnel comes a train, rushing into the station, and, after the engine has given a shrill whistle, stops. After a third signal with the bell, the engine whistles, and the train disappears into the opposite tunnel, the station-master and his assistant leave the platform, and the doors of the waiting-rooms close behind them.

Peat as Fuel.—The recent attempts to use peat in smelting iron and under locomotive boilers have been naturally looked upon with great interest in Ireland, which country has practically no coal, while one seventh of its whole surface, or 3,000,000 acres, consists of peat bog. Dr. Emerson Reynolds, who has given much time to the study of the subject, states that peat compares very unfavorably with coal in many ways. It is five times as bulky as coal, it contains from 15 to 25 per cent. of water, and seldom less than 10 per cent. of ash, and, bulk for bulk, its thermal value is only one-thirteenth of that of coal. The fresh peat, moreover, contains 35 or 40 per cent. of moisture, making necessary considerable expense for drying. During a coal famine some 20 years ago, Dr. Reynolds proposed converting the undried peat into gas, and this was successfully done in the shops of an Irish railway, the efficiency of a ton of peat used in this way for working up scrap iron being 60 per cent. of that of a ton of coal used as gas by the same method. Since then the extraction of ammonia from gasified peat makes this process more practicable. A promising new suggestion is that peat shall be used in making water gas, which can be conveniently supplied for domestic and industrial purposes.—*Invention.*

Freak of Electricity.—A curious freak of electricity has been discovered in connection with a leak in the mains of the Indianapolis Gas Company. In Illinois Street, buried 4 ft. deep, is a main that has been down for 52 years. It was abandoned 22 years ago because of its size, but the pipe is still in an excellent state of preservation. When the Citizens' Street Railway Company sunk its trolly-line poles in the ground, they were placed close to this abandoned main; some of them were flattened and rested against the pipe. The insulation wore off the top of the pole, and the iron became charged with electricity. The current ran down the pole into the ground until it came in contact with the cast-iron main, against which the pole rested. At that point the current burned a hole through the post and through the cast-iron gas-pipe. The current ran along this cast-iron pipe for 200 ft. north, where it came in contact with a 1½ in. wrought-iron service-pipe that crossed the old artificial main. At the junction of these pipes the current again showed its power by burning large holes in both pipes, and the melted metals formed into small globules, like shot, perfect in size and form, and these dropped into the old pipe. The gas released from the service-pipe followed south on the old main until it reached the electric post, and entered into the tube through the hole burned out by the current. The post was soon full of gas. A car passing made a spark that set it on fire, and the flames burst from the top of the pole. An examination of the service-pipe and the old main found them to be in excellent condition.

Large Steamers for the Southern Pacific Railroad.—The Southern Pacific Railroad announces that the Newport News Ship-building and Dry Dock Company is making preparations to build two 10,000-ton steamships at its plant. The site is now being piled for the blocking to carry the immense weight of the vessels. They are to ply between New Orleans and Liverpool.

Manufactures.

RESERVOIR DRAWING PEN.

We illustrate herewith a neat and ingenious arrangement of drawing pen that meets a want felt by every draftsman when engaged on heavy line work, and which is being placed upon the market by Messrs. Jackson Brothers, Limited, 50 Call Lane, Leeds, England. The constant dipping and wiping which are required under such circumstances with an ordinary pen, is a source not only of loss of time, but of constant annoyance, while it often results in the drawing or work becoming smeared and soiled from traces of ink accidently left about the fingers. In the pen shown, a reservoir for holding a supply of ink is fitted inside the holder, which, when once charged, will serve to keep the pen supplied for a considerable length of time. The arrangement of the pen will readily be seen on reference to the accompanying illustration. It consists of an ordinary

hinged-nib drawing pen, provided with a hollow metal handle, into which fits a cylinder *C*, which is shown withdrawn from the handle in the lower illustration. The rod or plunger *P* serves to draw the Indian ink into the cylinder *C*, while the tube *T* is provided to carry the ink to between the nibs of the pen; the whole reservoir attachment, as will be seen from the lower illustration, constituting in reality a miniature hand pump.

In using the pen the cylinder *C* is withdrawn from the handle by the milled gland *F*, the cylinder being charged by dipping the end of the tube *T* into the ink and pulling out the plunger *P* to its extreme position. The whole cylinder is then replaced in the handle, without, of course, disturbing the plunger, a slight push forward of which serves to replenish the supply in the nose of the pen as fast as it is exhausted. If it is desired at any time to interrupt the work, it is only necessary to blow out the ink remaining between the nibs of the pen, and the ink in the cylinder will keep good for days; while, further, if a line or two is required to be added to a drawing when the reservoir is empty, this can easily be accomplished, since the pen can be used exactly as an ordinary drawing pen; and if the reservoir becomes accidentally lost or damaged, an excellent drawing pen still remains; while, it may be added, the price of the pen, 4*s*., is less than is often charged for ordinary hinged-nib drawing pens of similar quality.

THE EXPOSITION FLYER.

The daily papers have made the fact very generally known that the New York Central & Hudson River and the Lake Shore & Michigan Southern roads have put on a new train—the "Exposition Flyer"—between New York and Chicago, which makes the run westward in 20 hours, and eastward in 20 hours and 15 minutes. On its first trip this train left New York on May 28th with a number of invited guests besides other regular passengers. The writer was among the party, and had a threefold purpose in making the journey—one to accept the hospitality of the officers of the New York Central Railroad Company, another to be a participant in the running of this first fast run and observe its phenomena, and, third, to visit Chicago and see the great show.

It should be added, perhaps, that this run was made just too late to be reported in the last number of The American Engineer, and therefore this somewhat belated account is given.

The train left New York at 3 P.M. on the date named, and made the run of 964 miles in 20 hours, or, to be exact, in two minutes less. There were nine scheduled stops, and several extra ones were made by reason of signals and other causes. The train consisted of one combination baggage, buffet and library car, with barber-shop and bath-room, approximate weight, 80,000 lbs.; three 16 section sleeping-cars, approximate weight, 96,400 lbs. each, making the total weight of cars in train 369,200 lbs. The engines used on the New York Central Road were like the one of which we have published illustrations in the article on American and English Locomotives during the present year. The weight of these engines with their tenders loaded is 203,500 lbs., making the maximum total weight of train 572,700 lbs. The average weight of train would, of course, be less, as the tender would not always be fully loaded. Besides these cars a dining car was taken on from Albany to Syracuse, and from Toledo to Chicago. Its weight was also about 80,000 lbs., making the maximum weight of the train 652,700 lbs.

The engines used on the Lake Shore Railroad were built by the Brooks Locomotive Works, and have 17 × 24 in. cylinders, 6-ft. wheels and 52-in. boilers, and weigh with the tenders loaded 174,600 lbs. The Lake Shore engines, it will be seen, are not nearly so large as those used on the New York Central Road. The difference in the size and weight of the two classes of engines has been the subject of a good deal of comment since these trains have been put on the road. On another page we give an engraving and description of the valves used on the Lake Shore engines. From this it will be seen that they are of the Allen type, with an exceptionally long travel and supplementary ports ⅜ in. wide. Indicator diagrams taken from these engines with these valves would be very interesting. The speed on the Lake Shore Road is 46.5 miles per hour, while on the New York Central it is 50.6. The engines on the latter road are built not only for hauling these fast trains, but must often be used for hauling trains of 10 and 12 cars at somewhat slower speeds. It would be interesting to know how the Lake Shore engines handle trains of this size.

The cars composing the train were all new, and have the Gould vestibule and the Leonard platform and hydraulic buffer. This is the invention of Mr. Arthur G. Leonard, Secretary to Mr. H. Walter Webb, Third Vice-President of the New York Central. The cars rode with remarkable steadiness, and the speed of the train did not impress those riding in it as being remarkably fast. The secret of the quick time is that it keeps at a regular rapid jog all the time, and the stops at stations are very short. On arriving at stations everything is in readiness, the inspectors begin their work at once, the engines are changed quickly, and there is little or no baggage to load or unload.

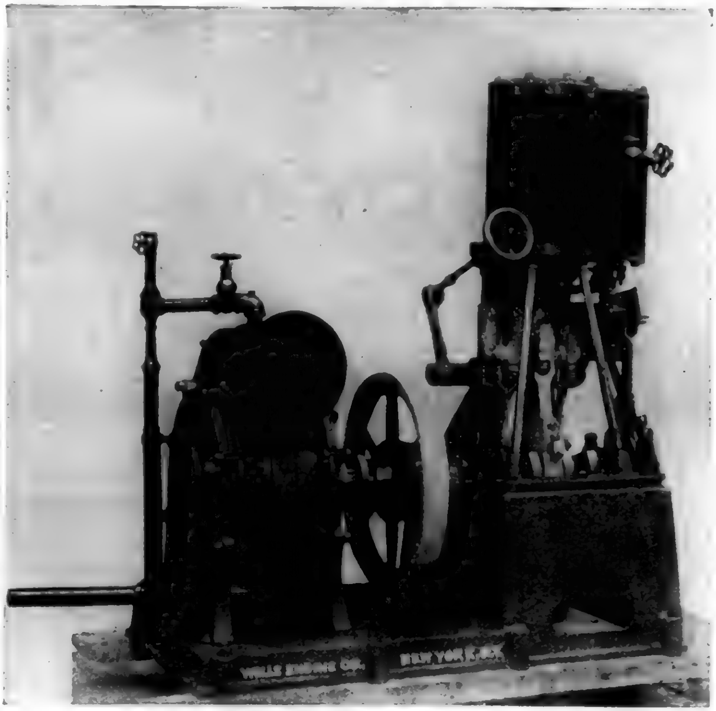
The officers of the New York Central assign much importance to heavy rails in fast running, believing that it is much safer and easier to maintain a high speed on stiff rails than it is on those which have more or less sensible deflection. There seems no room to doubt the practicability of making the run from New York to Chicago in 18 hours if the Lake Shore Line was relaid with heavier rails.

The return trip on the Exposition Flyer, which was made about 10 days later, was as successful and as prompt as the westward trip. In both cases the train arrived at stations slightly ahead of time.

THE WELLS ENGINE.

The steeple compound engine which we illustrate, and which is shown as driving a centrifugal pump, is made by the Wells Engine Company, of 91 Liberty Street, New York. The fundamental principles of the engine consist in the fact that the two pistons move in opposite directions to one another at all times, and with the same velocity, so that the reciprocating parts are practically balanced, and the engine will run with great speed upon its own base without the necessity of using holding-down bolts.

The proportions of the engine are such that the weight of the high-pressure piston, with its rod, cross-head and connecting-rod, weigh exactly the same as the low-pressure piston with its double rod, two cross-heads and two connecting-rods.



THE WELLS COMPOUND ENGINE.

The engine is operated by the Stevenson link motion, and is readily and easily handled.

The low-pressure cylinder is above the high-pressure, which is contrary to the usual construction of steeple compound engines; but this construction is followed with these engines on account of the two piston-rods which are used in connection with the low-pressure piston, and which straddle the high-pressure cylinder, coming down and taking hold of the two cross-heads on either side of the high-pressure cross-head. The engine is especially adapted for work where it is desired to make the best possible use of the steam, and at the same time where jar is very undesirable. This makes the engine especially valuable for yachts and work where it is impossible to put down a solid stone foundation. The engines are built in sizes ranging from 3-in. and 6-in. × 5-in. cylinders, up to 12-in. and 24-in. × 16-in. The same system has been carried out in quadruple expansion engines.

AMERICAN
ENGINEER
AND
RAILROAD JOURNAL.

(Formerly the RAILROAD AND ENGINEERING JOURNAL.)

PUBLISHERS' DEPARTMENT.

NEW ADVERTISEMENTS.

PENNSYLVANIA RAILROAD EXHIBIT AT THE WORLD'S FAIR.

A COMPLETE ILLUSTRATION OF THE PROGRESS OF AMERICAN RAILROADS.—STRIKING CONTRASTS BETWEEN THE PAST AND PRESENT.

THE World's Fair visitor who finds his way into that vast enclosure by the Sixty-fourth Street entrance will come almost immediately upon a building as architecturally attractive as any of the minor structures in all the great White City by the lake; a building classical in detail as well as in general conception, standing in the midst of a plateau of greensward with walls the tint of old ivory, and garnished with flags that reflect the brighter hues of the rainbow. While it is an annex, so to speak, of the great red and green and gold Transportation Building across the way, it is an annex complete in itself, and within and without exhibits in an exhaustive manner never before attempted, much less accomplished, the beginning, progress, and development of railroading in the United States as exemplified by the Standard Railroad of America. It is, in fact, the Pennsylvania Railroad Company's own edifice, and it presents an interesting and scholarly showing of that corporation's history from the first inception of one of its component parts in 1815, when the first charter was granted to a railroad company in America to construct a road from Trenton to New Brunswick, N. J., to the present time, when it controls nearly 10,000 miles of road penetrating 13 States, and with termini in New York Harbor, at the National Capital, in three great cities of the Ohio Valley, and at five of the great lake ports.

While the building's main façade is perhaps the more beautiful of the two 140-ft. sides of the structure, the rear view will doubtless prove the more attractive to the student of railroad progress, in that it presents, with its attendant features, an excellent reproduction of a model Pennsylvania Railroad station of the present day, with signal tower, tracks, ballast, switches, frogs, overhead foot-bridge, fences, and gates. The tracks in themselves are as indicative as anything else of the marked development in this branch of mechanics in the last 60 years, the exhibit showing, in juxtaposition with as fine a specimen of the standard Pennsylvania rail of 1892 as has ever been rolled, pieces of the Camden & Amboy rail of 1831, of the rail used on the old Portage Road over the Alleghenies, and of the very crude wood and iron rail with which the Madison & Indianapolis Road was originally laid. Some idea of the contrast may be had when it is stated that whereas the Camden & Amboy rail weighed only 35 lbs. to the yard, the standard rail of to-day, of which the examples shown are 100 ft. in length, weigh 100 lbs. to the yard, being nearly three times as heavy.

Upon the tracks is another contrast even more marked. Probably the most conspicuous, and certainly the most interesting, object in the display is the original *John Bull* train, where here rests after its 1,000-mile journey across the Continent from New York. The old engine itself—the oldest in America—which was constructed by George Stephenson, in England, and brought to this country in 1831 for use on the Amboy Division of the Pennsylvania Railroad, stands there to-day precisely as it was in 1836, after having had added to it such improvements as were then suggested to the minds of the American engineers. Its weight, with its somewhat cumbersome tender, is only 32,100 lbs., as against 100 tons, the weight of the ordinary standard passenger locomotive of today, and beside the modern machine, of course, it looks very much like a toy. The passenger coaches, glistening with a fresh coat of green paint, are so low that a tall man cannot stand upright within them; their brakes are worked by means of handles similar to those on the horse-cars of the present time, and the only method of lighting them is by a tallow dip in each end of each car. As example of the magnitude to which the railroad cars of to-day have attained, no better choice could have been made than the selection for exhibit, side by side with this tiny passenger train, of the two tremendous vehicles on which the mammoth Krupp guns were whirled from Baltimore to the Exposition; the manner in which the guns were carried being shown by means of full-size models, made of staff, of the standard 16-in. and 10-in. guns, such as are now used by the United States War Department.

This policy of contrast, which is so apparent without the building, is carried throughout the entire display, and the interior, with its relief maps, charts, models, lay figures, photographs, and relics, gives a better idea of the wonderful growth of the greatest railroad system of the country than could possibly be had in any other way. The walls of the great marble-floored hall, into which the visitor may enter from either the front or the rear, are lined with handsome mahogany show-cases, while the columns, so arranged as to form a colonnade on each side, are surrounded by folding frames for the display of thousands of exhibits that could be shown to advantage in no other way.

In arranging the display, the smallest details have not been neglected, and as an indication of the thoroughness with which these little matters have been looked after, the labelling of the objects with a descriptive label in five languages is especially noteworthy.

In the centre of the building, under the dome, upon a platform shaped like a Greek cross, are three relief maps that are certain to attract no little notice. They illustrate the changes in the methods of crossing the Alleghenies from the year 1832 to the present time, and have been prepared with such great care as to have won words of high commendation from scientists, whose attention has been called to them. One of these in particular, the largest of the three, which is 12 ft. long by 4 ft. wide, and which shows the old portage and the new portage roads, together with the present line of the Pennsylvania Railroad, including the Horseshoe Curve, Allegrippus, and the district of the Johnstown flood, is especially valuable as being the first and only relief map ever made of that section. The original map, from which the basis of the present work was obtained, was one which belonged to the late J. N. DuBarry, Vice-President of the Company. It was in lead-pencil, never having been filled in in ink, and was traced, so the legend runs, by President J. Edgar Thomson himself. The other two relief maps, or models which form two arms of the cross, show the Horseshoe Curve and Plane No. 1, with canal-boat, cars, and locomotives.

The rest of the floor space between the colonnades is dotted with pedestals and platforms upon which are models relating particularly to the developed system of transportation of today. On one side, for instance, is a beautiful reproduction in miniature of the double-decked ferry-boat *Washington*, one of the fleet plying between Jersey City and New York. In every particular the model maker has closely followed the original, and has succeeded in turning out a piece of work as nearly perfect in every detail as it is possible to imagine. On gala days it is proposed to decorate this little vessel with bunting, and arrangements have been made to light the interior with electric lights precisely as the boat from which it is copied is lighted. The method of handling freight cars in New York Harbor is shown here in the same way by means of models of a tug-boat and float. Toward the other end of the building are lay figures in uniform of the several classes of employés of the Company.

An object of considerable interest to many is a perspective map, 33 ft. long, showing the position of each train in motion

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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EDITORIAL NOTES.

IT is not often that the engineering world is called upon to witness the completion of a work nearly 2,500 years after it was first projected; but such is the case with the canal through the Isthmus of Corinth. Projected 600 years before Christ, agitated again 300 years later, actually begun by the Emperor Nero, it is completed in 1893.

IN another column we give a brief report of the tests of shells and armor plate recently supplied to the Navy Department. It must be exceedingly satisfactory to all concerned that there was no trouble over the acceptance of the plates or shells, although the manufacturers of the former failed to earn the premium offered in case their product resisted penetration of the shells.

AMONG the notable scientific events of the past month is the departure of the second Peary expedition for the north of Greenland. The *Falcon* is probably the best-equipped vessel that has ever set out for the Arctic waters, and we have probably heard the last of her until October or November, when it is expected that she will report, having left Lieutenant Peary and his party at their winter quarters. Then there will be nothing more for two years.

THE Government is after something marvelous in the way of a torpedo boat, but whether it will get it or no remains to be seen. It wants in a general way a boat that can dive under the protecting nets surrounding a vessel, explode a torpedo beneath her, and get away uninjured. For this simple little affair that any expert Kanaka swimmer could do on a small scale, Congress has authorized the payment of $200,000. Eight bids have been received, but only five submit definite plans. Nothing has been decided, and it is not probable that a contract will be awarded for some time.

THERE seems to be a constant complaint on the part of English manufacturers that the freight rates of the English railroads are abnormally high, while there is as constant a laudation, on the part of the railroad world, of the promptness with which freight is transported and delivered. The millennium would appear to be in sight if low rates and prompt delivery could be brought together. Occasionally by a special effort it is done in this country, but it almost always demands a special preparation and a special supervision. The question naturally arises, Cannot all the traffic be handled in this way, or is it too variable to admit of the constant maintenance of the force that would be required?

JUST after going to press with our last issue, the terrible disaster of the collision of the *Camperdown* and the *Victoria* took place, resulting in the sinking of the latter and the loss of several hundred lives. At first contradictory reports were circulated, and the responsibility for the collision was shifted from one officer to another; but the official reports to the Admiralty, as well as the court-martial inquiry that has been instituted, seem thus far to fix all responsibility upon the shoulders of Admiral Tryon, who gave the order for a manœuvre and then adhered to it, after his attention had been called to the fact that the distance which he had allowed between vessels was insufficient to perform the evolution.

THE old scheme—not so old as the Corinth Canal, however—of uniting the railway systems of North and South America is again on the tapis. It is reported that a feasible route has been surveyed from the southern boundary of Mexico to the northern frontier of Bolivia. While there can be no manner of doubt of the possibility of finding a suitable route from an engineering standpoint, it is a horse of another color when we look at it from the position of the investor who wishes to "touch" his dividends. It is well known that the country through which the route must lie is poor and subject to daily revolution, as it were, and it has furthermore been declared by engineers who have been over the route that the country is unable and will be unable for many years to supply freights or passengers in paying quantities. While we do not wish to be pessimistic, we still have a vivid recollection of a certain Rapid Transit Commission whose engineers evolved a perfectly practical scheme of underground railways, but which somehow could not be shown to offer a paying investment, and which no one would touch.

WORK OF THE MASTER MECHANICS' ASSOCIATION.

IN our last issue we gave a short *résumé* of the work accomplished by the Master Car Builders' Association, and it was due to a lack of space that the Convention of Master Mechanics received but a passing notice. The Convention opened on Monday, June 19, and was held in the same room as that of the Master Car Builders. This second convention works under the disadvantage of coming closely upon the heels of a previous week's work and amusement on the part of many of its members, who are tired with the one and satiated with the other; and this year the disadvantage was especially marked, owing to the disagreeable quarters in which the meetings were held. The room was directly

under a sloping roof, with no protection in the shape of air space, and but very inadequate means of ventilation. The result of this, when combined with the rays of the summer sun, was the production of a temperature and an atmosphere that was trying in the extreme, and which accounts for the half-hearted interest in most of the discussions that was manifest.

The entertainments by the supply men were simply a continuation of what had gone before; there was a grand ball in honor of the American Railway Master Mechanics' Association, in which perhaps a dozen members joined, and where male partners were scarce despite the several hundred men about the hotels. There were the boating parties on the lake, the fireworks, the music, and an excursion to Dunkirk, all enjoyable, but all like what had gone before.

The convention opened with the customary prayer, followed by the president's address. Mr. Hickey dealt in a general way with the labor problem and the construction of locomotives. Referring to the expense of locomotive performance, he said: "A majority of the largest roads throughout the country show an operating expense of from 22 to 25 cents per locomotive mile run, about 50 per cent. of this amount chargeable to fuel consumed in generating power." Referring to the locomotive returns for the month of March, 1893, as published in the July issue of the AMERICAN ENGINEER, we find 31 roads there reported. Of these 31 only eight show an expense of as much as 22 cents per mile run, or, in other words, 25 per cent. pay the lowest amount given by Mr. Hickey, and of these eight, four pay more than $3 per ton for coal. Some of the roads even drop below 15 cents per mile. We desire to call attention to this, because, while there is no doubt but that the locomotive does exhaust an immense amount of heat energy into the atmosphere, as Mr. Hickey says, we believe he has overestimated the expense, but agree that the various modifications in the valve motion of simple engines made for the purpose of reducing the loss have given but little promise of ultimate success. The address then went on to deal with the changes that were suggested to the speaker in locomotive construction.

The committee appointed to confer with that of the American Society of Mehanical Engineers on a Standard Method of Conducting Locomotive Tests made its report. There is nothing new and no innovation embodied in it. Those of our readers who are familiar with the methods adopted on the Baltimore & Ohio Railroad and the Chicago, Milwaukee & St. Paul know exactly what this report recommends. There are the same fuel and water measurements, and the use of the indicator, calorimeter and dynamometer car. The report is valuable chiefly as a record and basis of action as recommended by two great mechanical associations, and, as such, is to be referred to and consulted, though it adds nothing to the information of men who have followed the work already done, as reported from time to time in the columns of the technical press.

The report on Compound Locomotives simply gave the result of a year's experience on several roads. That the number of compound locomotives has increased is shown by the fact that 308 new engines were added to the equipment of the country within the year; but the reports of their performances are so varying that many members feel that they know less about that particular type of engine than they did before the first one was built. One member stated that the cost of maintenance is no more than for an ordinary engine, while another announced "an increase of repairs of 50 per cent." The New York, Lake Erie & Western report a saving of 8 per cent. of coal per car mile and 15.1 per cent. engine mile; the Chicago & North-western put the latter at 7.7 per cent., while the Cincinnati, New Orleans & Texas Pacific put the two figures at 45.5 per cent. and 33.7 per cent. respectively; the Cleveland, Akron & Columbus, at 15 per cent. and 32 per cent., and the Brooklyn Elevated evens up both at 24 per cent. Now, what is the jury of prospective buyers to do? How can they bring in a verdict? Really there seems no way out but to use the Scotch formula of "Not proven," and decline to say what is not proven. Frankly, we cannot presume to decide from such a jumbled mass of figures. Why should car mile saving be greater than the locomotive saving on one road and less on another? The mystery about this, as in all other things, lies simply in the fact that we do not know all the facts. When they are known, then, perhaps, the relative merits of the compound and simple engine will be settled. At the present writing it would seem that the compound will save *some* coal—just how much is an unknown quantity, and it is also unknown whether this saving is or is not counterbalanced by the extra expense of repairs and interest on first cost.

The chief work of the Committee on Wheel Centers and Tires is embodied in the recommendation to add centres of 70, 74, 78, 82, 86 and 90 in. in diameter to the standard centers already adopted by the Association.

The recommendations of the Committee on Boiler Attachments might be embraced in the general statement that they favored the use of flanged rather than screw fastenings; that they preferred to have check valves inside the boiler and not outside; that all cocks should be placed in locations where they are least likely to be injured or knocked off, and that the tendency to make attachments too light should be most especially guarded against. The committee announced themselves as of the opinion that water glasses were not a necessity, and the discussion of their report centered about this one heading. The convention apparently agreed with them, for it passed a resolution to the effect "That while the Master Mechanics' Association regards the water glass as a convenience and an additional precaution against low water, we do not regard it as an absolute necessity to the safe running of locomotives."

On Attachments between Engine and Tender the committee took a decided stand in favor of great strength, and particularly commended the Duluth, South Shore & Atlantic Railway practice, where the safety chains are held to the tender beam by double-ended staple bolts of 1¼-in. round iron, the loose ends being coupled to the under side of the engine draw casting by two pairs of pendent lugs cast on, through which (and through last link of chain) passes a 1½-in. horizontal cottered bolt. The danger to the men on the footplate from the tender mounting over the same is not considered to be great, and a plain flat chafing plate on the tender with a rounding one on the engine was recommended. As for the step question we are somewhat disappointed. We have repeatedly called attention to the dangerous and inconvenient form of the steps of American locomotives, and have contrasted them unfavorably with their English cousins, and when this committee was appointed we hoped that they would make some recommendations and present some plans that would serve to improve this particular detail of our locomotives, but they have really done almost nothing in this direction. The following is the full text of their report on the subject:

"A full third of the replies express a preference for short steps—that is, under 12 in. long; two specify 12 in., and the remainder run from 16 in. to 24 in., emphasis in many cases being laid on the necessity for high flanges on three sides, although some few do not use flanges.

"As to position horizontally, some say a low step is safe; but the distance of the lowest step above rail varies from one each of 12, 14 and 15 in., up to the more common height of 20 in. (that is, 24 in. above tie level), and there is an evident reluctance to having more than one additional step above the first step, however close to rail the first step be located or whatever be the height of the other 'risers.'

"It is not evident why the first 'riser' (that is, the distance from tie to first step) should so commonly be higher than the second and third 'risers,' except it be to clear snow or other obstructions at low level. Even any equal division of the total height by two steps into three equal 'risers' is not shown on any reply, although that would appear to be a more judicious and safer course for the men than the common practice.

"Two advocate adjustable steps (apparently to be altered to suit the personal ideas of each runner). This the committee thinks a mistake, believing a permanent fastening at a uniform height on all engines will, all things considered, offer less risk the year round.

"But two advocate steps at same level on both engine and tender, although there seems an additional element of safety in such a course. Apparently there is an endeavor to put all the steps on one of the vehicles (either engine or tender) when this is possible.

"The majority say that in material for steps wood and rubber have no appreciable advantages over iron; but few use wood, and one only mentions rubber. Roughened and perforated iron plate is the best practice, for although castings with serrated surface are common, the lighter weight and the freedom with which wrought iron can in winter be struck with a hammer (thus at once disengaging all ice) gives it the preference. The roughening of surface is usually done with a diamond-pointed chisel by hand."

In dealing with the unsatisfactory results that have frequently been obtained by railroads who have bought steel on chemical and tensile strength specifications, the Committee on the Tests of Iron and Steel said:

"Railroads buy all their steel on chemical and physical specifications, and, as far as your committee know, entirely ignore the question of expert inspection. In fact, it would be difficult to find to-day on any railroad an expert employed as such, who would undertake to grade a lot of 20 samples of steels, running from good tool steel to the cheapest products, in accordance with their prices and qualities, while at the same time there is good reason for believing that with proper training such grading could be very accurately done. This method of grading is practised in almost every line of trade. Step into a jeweler's establishment, and he will show you two diamonds of the same size and nearly the same appearance, but one is worth twice as much as the other. The dry goods man shows you silks varying in price from $1 to $10 per yard. The millions of bushels of wheat which change hands yearly are valued by expert inspection. The same is the case with almost every item of trade. In steel for boilers this kind of inspection seems to be entirely ignored.

"Your committee are decidedly of the opinion that certain requirements as to chemical composition, tensile strength and elongation do not insure the best quality of steel for fire-box work. It is not certain that further inspection as to character of crystallization, etc., will do so; but there are good reasons for believing that such inspection would be of material benefit if made by an expert.

"It is not intended that this system of inspection should dispense entirely with the present chemical and physical specifications; these have made, or at least should have been made, from analyses and tests as steel that have given good results in actual service, but necessarily ignore much that is due to manipulation, and it is the importance of the points ignored on which your committee dwell.

"It would be quite possible to get up very neat specifications, chemical and physical, of a loaf of bread; the crust must be so thick and of such a color; it must weigh so much per square inch; the pores must be of such a size and uniformly distributed; it must contain so much water, salt, gluten, starch, silica, phosphorus, etc., or, if we analyzed to its ultimate composition, so much carbon, hydrogen, phosphorus, etc. This would all be strictly in accordance with the composition and qualities of a good piece of bread; but if an expert with fair experience in gustatory requirements—and we have many such—were employed, he would tell us more and decide more definitely as to the qualities of that piece of bread, when he got a piece in his mouth, than by the most elaborate investigation on the line of the specifications outlined above. His decision also would be based on qualities which could not by any means be formulated in specifications."

This certainly has a ring to it that must appeal to many a man who has to deal with the apparent freakiness of fire-box steel that appeared to be capable of everything bad under the sun.

The Committee on Tender Frames submitted drawings of several types of iron and wooden frames, but declined to make any recommendation on the ground that "honors are about even" in the preferences expressed by members.

The report of the Committee on Malleable Iron Castings and the discussion which followed were not calculated to inspire confidence in that metal. Evidently some of the members have had experience with very poor samples, and they proceeded to give the whole a black eye. But when the matter is sifted down to facts it will usually appear that the castings so freely condemned have been of the cheap sort, or the patterns have been of thicknesses so variable from one part to another that there could be no evenness to the annealing. Quoting from the report, they say: "We have reached the conclusion that there is no evidence to indicate the probability that malleable iron castings can be generally used as a substitute for expensive forgings. Malleable iron castings, as now used in connection with locomotive construction, are principally either substitutes for gray iron castings or for small and inexpensive forgings. The committee have not reached a single suggestion that malleable iron can be economically introduced in place of the larger and more expensive forgings which are now used in locomotive construction."

The last regular report was that on Smoke Consumers, and, as might have been anticipated, the committee found little or nothing that was new to bring before the convention. It frankly stated that "it is unnecessary in this report to go further into detail in the matter of combustion, as full information can be readily obtained from well-known books." The whole report was merely a *résumé* of the principles laid down in Clark's "Fuel and Its Combustion."

One of the features of the Master Mechanics' Convention

is the noon hour discussion of topical questions. This really amounts to a talk between the members, and usually takes the form of suggestions to some member who asks for information. A question brought up this year was that of the fluting of side rods, and whether it were best to do it on a milling machine, under the hammer, or with a planer. The general opinion seemed to be in favor of the milling machine as being the most expeditious and satisfactory. The planer is too slow and expensive, and the work of the hammer leaves much to be desired in that, while the actual tensile strength of the skin may be greater than that of the metal in the interior of a bar, the unevenness of the surface is apt to destroy the excess strength and leave the rod weaker than where the finished metal as left by a machine is used. It was strange that the superiority of the miller in point of speed over the planer was not brought more prominently to the front; but the members speaking did not seem to realize this, whereas, in point of fact, it is probable that the milling machine will do the work in one-third the time required by the planer.

The topic of broken cylinders elicited the information that the trouble could be remedied in the very simple manner of using more metal at the weak spot. Master mechanics have been apt to forget that in increasing the diameter of their boilers and raising them so far above the rail, they are adding to the leverage exerted on the metal of the saddle at the junction of the frame. But more metal, less breakage, is all that is to be said.

One of the pleasant incidents of the convention was an address by Mr. Fox, of Leeds, England, on the subject of Boiler Steel. His remarks on the care which it is necessary to take in order to procure satisfactory results perhaps told nothing that was absolutely new to those who are in any way familiar with the processes of steel making, but they certainly ought to serve the purpose of driving familiar facts home. He said that they did not mind very much the amount of silicon or carbon in the pig iron, but they were careful to select such as had the smallest amount of phosphorus; and then they considered it necessary to know exactly the composition of the fuel that is used in every part of the work, so that the resulting gases shall have the same value in purity as the pig iron. With these together, and both clear of sulphur and phosphorus, a fair and reasonable result may be expected. To this must be added pure materials in the sand and gannister used in the furnace linings and the brick from which it is built. For fire-box purposes Mr. Fox recommended about .11 of carbon. He made many suggestions relative to the rolling of the plates and the tests to which they should be subjected, with a short *résumé* of the specifications of the Board of Trade, the Admiralty and those of the French and German governments.

Before adjournment the usual suggestions for the next place of meeting were handed in, and they covered the whole country pretty thoroughly; but as the matter is in the hands of the joint committee of the two associations, no prognostications can be made as to where they will locate.

BOOKS RECEIVED.

The Slide Rule. Third Edition. By William Cox. Keuffel & Esser Company.

The Official Railway List. A Complete Directory of Officers of Railways in North America, and Handbook of Useful Information for Railway Men. Twelfth Year. Railway Purchasing Agent Company, Chicago.

Visitors' Directory to the Engineering Works and Industries of Cleveland, O. Civil Engineers' Club of Cleveland, O.

A Practical Treatise on Foundations. By W. M. Patton, C.E. John Wiley & Sons, New York.

Reference Map of the United States. The American Society of Civil Engineers.

Engineering Works in St. Louis and Vicinity. The Engineers' Club of St. Louis.

Timber Physics. Part II, Progress Report United States Department of Agriculture, Forestry Division. Under the Direction of B. E. Fernow, Chief of Forestry Division.

Proceedings of a National Convention of Railroad Commissioners, held in Washington, D. C., April 19 and 20, 1893.

The Electric Transmission of Intelligence and other Advanced Primers of Electricity. By Edward J. Houston, A.M. The W. J. Johnston Company, Limited, New York.

TRADE CATALOGUES.

Cold Saw Cutting-off Machine. Newton Machine Tool Works, Philadelphia.

Extracts from Various Papers on the Subject of Steel Railway Ties. Standard Steel Railway Tie Company, New York.

Extracts from Various Papers Regarding the Consumption of Wood for Railroad Ties. Standard Steel Railway Tie Company, New York.

Exhibit of Locomotives at the Columbian Exhibition by Brooks Locomotive Works, Dunkirk, N. Y.

Exhibit of Locomotives at the Columbian Exhibition by the Baldwin Locomotive Works, Philadelphia.

Mexico? Si, Señor. By Thomas L. Rogers. Mexican Central Railway Company, Limited, Boston.

Calorimeters, Throttling and Separating, designed by Professor R. C. Carpenter, Cornell University, manufactured by Schaeffer & Budenberg, 66 John Street, New York, 5¾ × 9 in., 16 pp. This pamphlet contains engravings of the two kinds of calorimeters mentioned in the title, with explanations of the principles on which they work and of their construction and directions for their use, all of which are very clear. The last page contains a short article on the Importance of Determining the Amount of Moisture in Steam.

A. Aller, of 109 Liberty Street, New York, sends us his catalogue, 3½ × 6 in., 64 pp., of engineering specialties for steam, oil, gas, water and chemicals. These specialties embrace the Korting double-tube injector, adapted to a variety of purposes, including stationary and locomotives engines, the steam-jet pump, acid siphon pump, cellar drainer, cesspool pump, steam-jet air exhauster and compressor, steam-jet blower, furnace blower, ventilator, chimney draft improver, condensers of various kinds, etc. The catalogue also includes the Curtis regulator in all its various applications.

The Robert Pool & Son Company, of Baltimore, Md., have recently issued a new edition of their list of gearing, pulleys, sheaves, etc., which they manufacture. It is 5¼ × 7¾

in., 206 pp. From a rough calculation we find that it contains 1,962 different sizes of spur gears, 1,476 bevel gears, 400 miter and limiting tooth gears, 650 bevel mortise gears and pinions in pairs, 172 spur mortise gears, 262 pinions for spur mortise gears, besides a variety of pinions for face mortise gears, worm gears, sheaves for transmitting power by ropes, chain sheaves, and pulleys. The list, the Company say, "embraces only such sizes as we are now prepared to make, but our system of machine molding enables us to produce most anything in this line at very short notice."

WARD'S PATENT SECTIONAL SAFETY HIGH-PRESSURE BOILER, manufactured by Charles Ward, Charleston, W. Va. We are in receipt of two folders 9 × 12 in., one of four and the other eight pages, the first description of this boiler, which has special interest at the present time, as the United States coast defense vessel *Monterey* is equipped in part with this type of boiler. The one circular describes its construction, and gives a sectional view and a table of dimensions of this steam generator, which has recently been attracting a good deal of attention.

The second circular is made up of newspaper comments on the adoption of this form of boiler in the United States Navy. The engineering public will await an official report of their performance with much interest.

FRASER & CHALMERS, Chicago, Ill., Introductory Catalogue, Power Mining and Metallurgical Machinery, and Catalogue No. 32, Ore Sampling Machinery. These two publications are 6 × 9 in., one of 14 and the other 20 pp. The first of them describes the engines, boilers, steam power plants, hoisting engines, and general mining machinery manufactured by this firm, and calls attention to their exhibits in the Mines and Mining Building and in Machinery Hall at the Columbian Exhibition. The second volume is descriptive of H. L. Bridgman's ore sampling machines, which are manufactured by this firm.

The same firm also send us their two catalogues, Nos. 41 and 42; the first is on the use of their machinery in the Kimberly diamond mines, and the second on rock drills at the Robinson gold-mine in Africa. Both give many interesting facts which are little known in this country.

THE MODERN TRAVELING CRANE. *By Alexander E. Outerbridge, Jr.* This is a reprint of a paper read before the Franklin Institute of Philadelphia, which is largely descriptive of the cranes made by Messrs. William Sellers & Company, Incorporated, by whom it is issued. It contains a double page folded plate showing the interior of the erecting shop of the Baldwin Locomotive Works, with the cranes for hoisting locomotives. The paper itself gives a statement of the general principles on which cranes are constructed, and a description of those shown in the engraving referred to. The paper has more of a popular than a technical character, and will be read with satisfaction by any one interested in the subject.

A novelty about this publication is its cover, which is made of what is called "pantasote leather," a flexible sort of coarse paper, which is finished on one side so as to have a close resemblance to grained leather. It is pleasant to handle, and has the appearance of being durable.

THE BUILDERS' IRON FOUNDRY, of Providence, R. I., has issued a small catalogue, 3¼ × 5¼ in., 36 pp., in which the different kinds of Globe special castings and fittings for water works, mills and railroads, which they manufacture, are described. These include what they call their Globe specials, which are connections of different kinds for water-pipes. The body of these connections is made of a globular form, for which it is claimed that it "avoids all useless accumulations of metal, and offers the greatest possible resistance to bursting strains. It renders the castings comparatively light and compact, and makes it possible to combine a number of branches in a single casting; reducers and branches may be advantageously combined, and angle bells or tangent branches made without objectionable features." The catalogue gives dimensions and prices of crosses, branches, reducers, elbows, sleeves, curved and bent pipes, plugs, caps, strainers, and flanges. In the latter part are illustrations and descriptions of the Venturi water meter, which is manufactured by this Company. The catalogue ends with a very useful table, giving the thickness of metal and weight per length of cast-iron pipes.

GRANT'S GEAR BOOK FOR 1892, issued by the Lexington Gear Works, Lexington, Mass. This is primarily a catalogue showing the different kinds of gears manufactured by the publishers. It opens with directions for ordering gear wheels, which are followed by instructions for drawing them, all of which will be found useful by the user of these mechanical appliances. The rest of the book contains illustrations, descriptions and lists of the various sizes and kinds of gears made by this Company. These embrace some curious examples, which include racks, pinion-rods, which are rods with teeth cut on them, noiseless fiber gears, which are made of sheets of some kind of fiber riveted together, and composite fiber gears which consist of alternate sheets of steel and of fiber riveted together. There are also solid cemented raw-hide gears, level gears with directions for drawing them, worm gears, balanced worm gearing, which we have not space to describe, spiral gears, ratchets, worm hobs, elliptic gears and directions for drawing them, and brass gears of various kinds. An engraving and description of a 24-in. gear cutting machine, which the Company manufactures is given, and the book ends with a list of the various kinds of gears kept in stock.

THE BROWN & SHARPE MANUFACTURING COMPANY, of Providence, R. I., send us a very neatly printed volume, 6¾ × 5⅜ in., 66 pp., which is without a title. In the preface it is said that the objects for which it was printed are "to give a brief description of our works and our business, Providence and the neighboring cities, and to offer some suggestions of use to those who are traveling in America for the first time, and to extend an invitation to visit our shops and our exhibit."

The frontispiece is an engraving of their works as they were in 1872, and another one is given of the present buildings. A brief description of their establishment and the kind of work they do in it is added. This is followed by descriptions of Providence and its environment, with a chronological table of various important events which have occurred therein. A few pages are devoted to Newport and Boston. These are followed by "Suggestions in Regard to Living and Traveling in America," a Cable Code, Remarks and Maps of Chicago and the Exposition, a List of Consuls at Chicago, a Railroad and Steamboat Time-Table, and ends with a bird's-eye view of the Columbian Exposition. The paper and printing are all of the best.

CATALOGUE OF TURRET MACHINERY, built by John L. Bogert, Engineer, Flushing Iron Works, Flushing, Queens County, N. Y., 5¾ × 9⅜ in., 17 pp. The title of this publication indicates its character. The turret machines which it describes are similar to, and, in fact, are lathes provided with a revolving turret. These turrets, the catalogue says, may be constructed to carry any desired number of tools, but are usually bored with six holes. They are applied to a variety of machines, and in different ways. They are made to revolve round axes perpendicular, inclined and parallel to the spindle.

They frequently replace tail stocks, are mounted on cross-slides, and, where taper work is done, are controlled in their movements by swiveling slides, or taper bars. Each hole in the turret-head has a sort of spindle fitted in it which carries a tool. When more than one operation is necessary to bore, face, turn or thread small pieces, these tools are successively brought into operation by revolving the turret and sliding it toward the face-plate of the machine.

The pamphlet contains engravings of five different types of these machines, with illustrations of friction clutches and counter-shafts. The engravings, printing and paper are all of excellent quality.

The J. T. Case Engine Company. New Britain, Conn.

This firm send us a neat folder and small pamphlet, $5\frac{1}{4} \times 6\frac{3}{4}$, 27 pages, in which the engines made by this firm are fully and very well illustrated. These consist of small engines varying from 2.7 to 25 H. P. It is not easy to explain the peculiarities of these engines without engravings. To understand their construction, the reader should imagine a solid cylinder with its axis horizontal and held so that it can turn in bearings like the journal of a shaft or axle. Now, suppose that this cylinder has a cylindrical hole bored in the middle of its length, the axis of which is at right angles to that of the solid cylinder, and that a piston is fitted in this cylindrical hole, with a rod connected directly to a crank below. It is obvious that the piston can work in this hole like any ordinary piston working in a hollow cylinder, and that the solid cylinder in which the cylindrical hole is bored can oscillate in its bearings. Its action, then, and that of the piston will be similar to that of a cylinder of an ordinary oscillating cylinder engine, the difference being that the diameter of the trunnions is somewhat greater than the whole length of the engine cylinder. In fact, it is one oscillating engine with trunnions large enough to contain the cylinder and piston.

This method of construction is applicable only to small sized engines. They are made of various patterns. The cylinders, piston-rods, and cranks are all inclosed inside of a casting, which is made in the form of a stand, a bracket, or a hanger for convenience of application to various kinds of light work.

The engravings in the volume before us are very good, although the construction of the engine would have been made clearer if longitudinal and transverse sections had been given of one of the engines.

The cover of the catalogue is especially neat in design, color, and typography.

Wells Balanced Marine Engines. *By the Wells Engine Company*, 91 Liberty Street, New York, $5 \times 7\frac{1}{2}$ in., 19 pp. The purpose of this pamphlet is to describe various forms of the Wells compound and quadruple-expansion marine engines. The engine consists of two vertical tandem cylinders, the high-pressure, or smaller cylinder, being below the larger, or low-pressure cylinder. The former has a single piston rod, which is connected with a central crank in the usual way. The low-pressure piston has two piston rods which are placed on each side or "straddle" the small cylinder, and are each connected by separate connecting-rods with cranks opposite to the central crank, to which the high-pressure piston is connected. The two pistons, therefore, move in opposite directions, and as their weights are made equal, they of course balance each other, or, as stated by the author, "the high and low-pressure pistons with their connections, being equal in weight and attached to opposite ends of the levers, moving in opposite directions in the *same plane*, the thrust of one is perfectly counteracted by the other permitting 'any' speed without vibration. . . . The weights and forces being equally applied to opposite crank-pins, moving in opposite directions in the *same plane*, the cranks become the beams or levers of balance, and there being no weight of parts to be lifted and no friction due to steam pressures to overcome, the steam forces applied to the pistons and the momentum forces stored in its moving parts are all transformed into crank motion."

It is claimed—and there is good reason for the claim—that these engines will run steadier than other engines, and will relieve the hull of a boat or ship of all strains, jar and vibration. Increased power, more economy of fuel, greater durability, and less weight are all claimed with a capacity for higher speed.

The quadruple-expansion engines have two pairs of cylinders placed side by side, and connected to six cranks on the main shaft.

The pamphlet is well printed, the engravings are good, and the engine described has much to commend it.

Illustrated Descriptive Catalogue of Labor-Saving Patent Wood-Working Machinery, *Manufactured by J. A. Fay & Company.* Cincinnati, O., U. S. A.

This is one of the most magnificent trade catalogues that has ever been brought to our notice. It is $7\frac{1}{4} \times 11\frac{1}{2}$ in. on size, and contains 337 pages of engravings and text printed in heavy coated paper. These are bound in flexible covers of a very highly ornamental design, on which are represented fac-similes of the different medals awarded the firm at different exhibitions.

In the introduction it is said that this new catalogue is in tended for "the users and those interested in the progress and improvements made by us in wood-working machinery, since our 1885 edition, for the rapid and economic conversion of wood into the many diversified uses, purposes, and shapes demanded by the present necessities, new methods and systems of planing mills, sash, door, blind, furniture, wheel, carriage, plow, and agricultural-implement shops, railway and car works, arsenals and navy yards, etc. . . . The variety of the machines has been increased until they now reach nearly 400, and the wants of every class of manufacture have been anticipated."

The book begins with "suggestions" for ordinary machines. These are followed by rules and directions for arranging shafting, with engravings of couplings, pulleys, hangers, etc., manufactured by the firm. This is followed by illustrations and descriptions of planing machines, of which there are 32 engravings. Ten of these are printed on folded insets. With one exception they are all ordinary wood engravings of the very best kind. The descriptions of the machines are ample. At the close of this department various tools and appliances used with these machines are illustrated and described.

After the planers, nine different kinds of sash and molding machines are illustrated and described. This part is supplemented by illustrations of various kinds of cutters used on these machines. Eight different kinds of panel, sash, and door machines are shown, two jointing and hand-planing machines, six varieties of wood-workers, with illustrations showing the different kinds of work and methods of doing it on these machines.

Five molding machines and specimens of work done on them are illustrated, a number of carving and dove-tailing machines, 12 different kinds of tenoning machines, two car gaining machines, over 30 boring and mortising machines, nearly 50 different kinds of sawing machines, 11 wood-turning lathes, eight or 10 sand-papering machines, and 23 machines for making small wheels, are elaborately illustrated and described. Besides these, there are many illustrations of small tools used in connection with the larger machines.

The book ends with a good index, which is very much to be commended.

It would be difficult to praise the engravings too highly. They are all examples of the very best illustrations of this kind. There is no sort of illustration by which a machine can be shown so perfectly as it can be by wood engraving when the work is done by a master in the art. All the engraving in the Messrs. Fay's book is of the very best, and this is also true of the typography. The whole book is very creditable, and worthily represents the firm by which it has been published.

NOTES AND NEWS.

John Fritz Receives the Bessemer Medal.—At a meeting of the Council of the American Society of Mechanical Engineers, held in June—the report of which reached us just too late for publication in our July number—resolutions were adopted congratulating Mr. John Fritz on the action of the Iron & Steel Association of Great Britain in conferring on him the "Bessemer Medal." Mechanical engineers in this country generally will agree with the resolutions of the Council, that the "genius, skill and industry" of the recipient have merited the distinguished honor conferred on him.

Appropriation for Flying Machine Experiments.—The Bavarian Ministers of the Interior and Education have made a grant of 1,600 marks to the Aeronaut Koch for an experiment with his guidable flying machine.

Ventilation for the Pennsylvania Train Shed at Jersey City.—The Pennsylvania Railway is putting in an elaborate apparatus for the purpose of ventilating the train shed at Jersey City. Contrary to the expectation that it would be well enough ventilated by natural means, it is found to be very hot in warm weather, and is rendered worse by the many locomotives running in and out or standing on the tracks. The Sturtevant system of ventilation by blowing cold air from below has been adopted.

Cast-Steel Bells.—Herr Thomas Krause, Musical Director of the choir in the church of St. Nicholas and St. Mary, in Berlin, recently inspected the foundry for cast-steel bells of the Bocheimer Company, at Bochum. He writes to the Sunday edition of the *Reichsboter* that the material from which bells should be cast lies between bronze and cast steel. Although the proportions of bell metal (78 parts of copper to 22 parts of tin) are well established, the difficulty of procuring a pure, sweet tone lies in the fact that unadulterated metals, and especially tin, are almost impossible to procure. The use of a tempered cast steel causes much less care and anxiety. Its preparation puts an end at once to all adulteration, for, for a given chemical composition, only certain raw materials can be used. As to which is the best, cast steel or bronze, is a mooted question. Bronze may be cast so as to give a perfectly sweet, clear tone, while cast steel does not ordinarily reach the same degree of perfection. Again, take the old cast-steel bell made by the Bochum Company in 1860 and sent to London. It has a harsher tone than one of bronze would have; but if its iron clapper were replaced by one of bronze this harshness would no longer exist, but the tone would be stronger and more penetrating than that of a bronze bell. A cast-steel bell costs about one-half as much as one of bronze, while they can be furnished of any desired size, tone, and softness of effect.

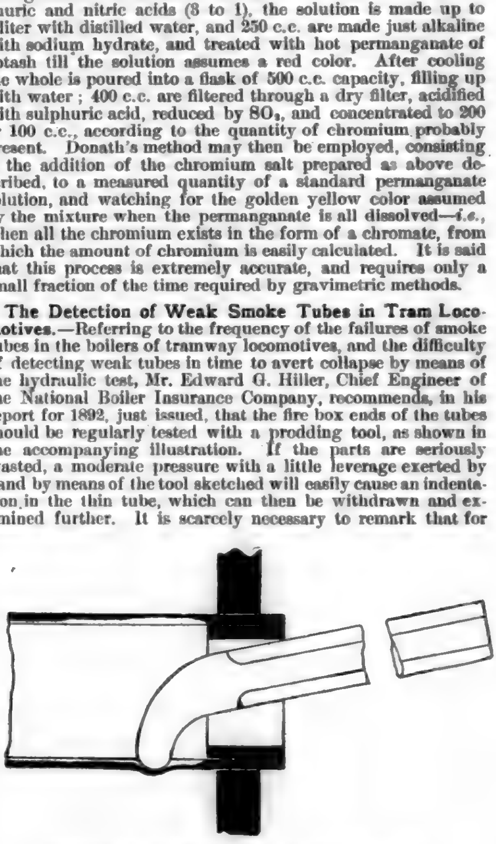
Novel Method of Photographing the Camp of an Enemy.—An exceedingly interesting English invention consists of a camera combined with a parachute, especially designed for obtaining photographs of fortifications and of the camps of the enemy, although pictures may also be made for general surveying purposes. The parachute is snugly folded in a thin case at the end of a rocket, which is fired to the required height and burst open by means of a time fuse. The explosion sets free the parachute, which is protected from injury by means of a casing of asbestos. The parachute has a number of thin umbrella ribs, and these are forced outward and kept in that position by means of a strong spiral spring.

From the parachute a camera is suspended, and a string held by the operator is attached by a universal joint to the bottom of the device, for the purpose of pulling the parachute back. The camera is fitted with an instantaneous shutter, operated by clockwork, so as to give several exposures at intervals. At the back of the box is an arrangement by which the plates can be manipulated the same as clockwork. A swinging motion can be given the camera by the operator, and this will enable him to obtain successive pictures over a wide area.

The whole arrangement is exceedingly ingenious, and if it can be employed practically it marks an important step in the science of modern warfare.—*Chicago Times.*

Determination of the Amount of Chromium in Steel.—A volumetric method for determining the amount of chromium in a specimen of steel has become a great metallurgical desideratum since the good qualities conferred upon steel by its addition have become generally known. Such a method is described by G. Giorgis, of the University of Rome, in the *Atti* of the *Accademia dei Lincei.* It is founded upon the formation of potassium chromate and hydrated manganese sesquioxide on adding a solution of potassium permanganate to a solution of sesquioxide of chromium in potassium hydrate. Ten grammes of the steel are dissolved in a mixture of sulphuric and nitric acids (8 to 1), the solution is made up to 1 liter with distilled water, and 250 c.c. are made just alkaline with sodium hydrate, and treated with hot permanganate of potash till the solution assumes a red color. After cooling the whole is poured into a flask of 500 c.c. capacity, filling up with water; 400 c.c. are filtered through a dry filter, acidified with sulphuric acid, reduced by SO_2, and concentrated to 200 or 100 c.c., according to the quantity of chromium probably present. Donath's method may then be employed, consisting in the addition of the chromium salt prepared as above described, to a measured quantity of a standard permanganate solution, and watching for the golden yellow color assumed by the mixture when the permanganate is all dissolved—*i.e.*, when all the chromium exists in the form of a chromate, from which the amount of chromium is easily calculated. It is said that this process is extremely accurate, and requires only a small fraction of the time required by gravimetric methods.

The Detection of Weak Smoke Tubes in Tram Locomotives.—Referring to the frequency of the failures of smoke tubes in the boilers of tramway locomotives, and the difficulty of detecting weak tubes in time to avert collapse by means of the hydraulic test, Mr. Edward G. Hiller, Chief Engineer of the National Boiler Insurance Company, recommends, in his report for 1892, just issued, that the fire box ends of the tubes should be regularly tested with a prodding tool, as shown in the accompanying illustration. If the parts are seriously wasted, a moderate pressure with a little leverage exerted by hand by means of the tool sketched will easily cause an indentation in the thin tube, which can then be withdrawn and examined further. It is scarcely necessary to remark that for



METHOD OF DETECTING WEAK BOILER TUBES.

the proper use of this mode of examination the fire-box should be accessible, so that there may be no difficulty in getting to every tube. Referring to several instances in which serious scalding had resulted in consequence of the blowing out of plugs driven into the ends of defective smoke tubes, he points out the importance of such tubes being renewed at once, pertinently remarking that plugs of the nature referred to have repeatedly proved themselves to be unreliable, and on many occasions have given rise to serious accidents.

The Three Classes in Europe.—A table which appears in the *Bulletin de Statistique et de Legislation Comparée*, which is published by the French Minister of Finance, exhibits the vast disproportion of the number of railway passengers carried in the different classes of carriages in various European countries, which is interesting.

In the first-class the proportion of the whole number of passengers carried was, per cent.: Germany, 0.6; Austria, 1.2;

Russia, 1.4; Switzerland, 2.2; Great Britain, 3.6; Belgium, 3.9; Italy, 4.8; Holland, 7.0; and France, 8.0.

In the second-class the proportion per cent. was: Russia, 7.1; Great Britain, 8.1; Germany, 10.2; Austria, 12.7; Belgium, 12.8; Switzerland, 19.7; Holland, 23.0; Italy, 25.9; and France, 36.0.

In the third-class the percentage was: Russia, 91.5; Germany, 89.2; Great Britain, 88.3; Austria, 86.1; Belgium, 83.3; Switzerland, 78.1; Holland, 70.0; Italy, 69.3; and France, 56.0.

The proportion of receipts from the first-class was: In France, 21.0; Italy, 17.5; Holland, 16.6; Belgium, 14.8; Great Britain, 12.4; Switzerland, 11.4; Austria, 7.5; Russia, 6.2; and Germany, 4.9 per cent.

The percentage of receipts from the second-class was: In Italy, 36.6; Holland, 36.2; Switzerland, 34.4; Austria, 27.6; France, 27.0; Germany, 26.9; Belgium, 25.1; Russia, 15.1; and Great Britain, 10.1.

The percentage of receipts from the third-class was: In Great Britain, 77.0; Germany, 68.2; Austria, 64.9; Russia, 64.1; Belgium, 60.1; Switzerland, 54.2; France, 52.0; Holland, 47.2; and Italy, 45.9.

It should be noted that in the third-class, both for receipts and numbers, are included all classes below the second-class.

Testing the Hardness of Metals.—In Dingler's *Polytechnisches Journal* of December 16, 1892, there is a description of a new form of apparatus in use at the Royal Research Laboratory, in Berlin, for testing and comparing hardness of different substances.

The substance to be tested is prepared with a smooth or polished face. The principle utilized is the varying breadths of scratches made on such surface by a diamond point under constant pressure. The point is made as nearly as possible conical, with an angle of 90°. Hard steel and steel plated with iridium have been tried, but are not as satisfactory in action as the diamond.

The apparatus includes a beam balance for producing any desired pressure on the diamond point, which is attached to one end of it, and a holder for the substance under test. The holder is arranged to slide on a track, and as it is moved to and fro a transverse motion is given, thus resulting in the ruling of a series of lines on the surface.

The breadths of the lines are then measured by means of a microscope with eyepiece micrometer, the results being noted in any convenient unit. The hardness is then taken as inversely proportional to the breadths of the lines.

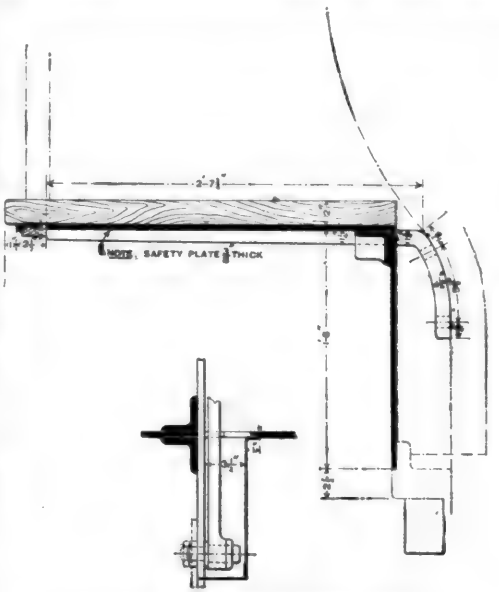
Following are some results expressed in arbitrary measure: Lead, 168; tin, 284; copper, 398; zinc, 426; nickel, 557; soft steel, 765; glass, 1,355; hard steel, 1,375.

Alloys of copper and tin were tested with the following results:

Composition. Cu. %.	Sn. %.	Hardness.	Composition. Cu. %.	Sn. %.	Hardness.
17	83	364	75	25	1,100
20	80	378	80	20	1,020
50	50	625	96	14	675
66	34	830			

A New Method of Rolling Old Steel Rails.—In utilizing old steel rails it has generally been customary to split apart the head, neck, and base, heat each part separately, and roll the pieces out into small plates. Several Western mills have lately adopted a new method of rolling, known as the McCloud process, by which no splitting is necessary. The rails are carefully selected—only those weighing 56 lbs. and upward per yard being used—and cut into pieces from 3 to 6 ft. long. The pieces are then heated and passed six times through a set of rolls. On the first pass the base of the rail is bent over to the side, on the next pass it is bent more and the head is somewhat corrugated, on the third pass the rail begins to look like a plate, and the other passes complete the process. The rolls are so designed that the metal is gradually flattened out without being bent over on itself, which would be highly injurious, since the steel does not weld. The finished plates are about ¼ in. thick, and from 8 in. to 10 in. wide, depending on the section of the rail from which they are made. They have been used for a variety of purposes, especially for making wire nails, for which they seem especially suited. The inventor of the process, Sidney McCloud, has also invented another system of rolls for wrapping narrow plates into a bar, which is much stronger than a solid piece of the same size. The reason of this additional strength is to be found in the fact that if the outside layer of metal is broken the inner layers are intact, and will resist further strain, while in the case of a piece of solid steel the rupture of the skin is fatal. The seams in these wrapped bars are said to be scarcely perceptible to the naked eye, and only appear when the metal is bent over and twisted off, which requires a great amount of force. The advantage of using these wrapped bars under certain conditions will be better understood when it is recalled that steel frequently bears a stronger resemblance to a refined, ductile cast iron than to a fibrous wrought iron, and partakes so largely of the character of cast iron that a small scratch on its surface may cause serious trouble if the piece is solid and exposed to vibratory strains.—*American Manufacturer.*

The Safety Plate under Running Board.—The Southern Pacific Railway Company have added a safety plate beneath the running board of their locomotives, to protect the enginemen from injury in case of the breakage of the engine rods. It consists of a ⅜-in. plate located just beneath the wooden running board and held by brackets, as shown in our engraving. While three-eighths may not absolutely prevent the end of a side-rod that is being whirled about by the crank-pin from coming up through the floor, still at the same time it will afford considerable protection, and probably so protect the foot plate that the engineman would not be seriously injured. At any rate, we think that there is no doubt whatever but that almost any one of our readers would prefer to take their chances with the plate than without it. The idea is a very simple one and so easily applied that it seems that it would obtain a wide practice as one of the safeguards which is to be given to enginemen. A reference to the list of accidents to locomotive engineers and firemen, which have been published in the pages of this journal since April, show that there have been eight cases of broken side-rods which have inflicted more or less injury upon enginemen in four months, so that such a protection as the one illustrated cannot be without its uses.



SAFETY PLATE UNDER RUNNING BOARD.

Test of Armor-Piercing Shells.—There was a highly successful test of the largest armor-piercing shells ever manufactured in this country at the naval proving grounds at the Indian Head on July 5. The shells were the product of the Carpenter Steel Company, and represented a lot of about 250 which the Government has contracted to purchase from that concern. The tests were under the personal supervision of Commodore Sampson, Chief of the Bureau of Ordnance. Each shell weighed 850 lbs., and is intended for operations against armor. Such shells do not contain bursting charges, but cause damage by the force of impact alone. The shells were discharged against one of the several creusot plates recently bought by the Navy Department for experimental purposes. Only two shells were tested. The first had a velocity of 1,300 ft. a second. It penetrated 16 in. of plate and backing, rebounded, and was found to be only slightly distorted in body.

The second shell had a velocity of 1,325 ft. a second. It went through both plate and backing and fell 9 ft. in rear of the target. It was practically undeformed when examined. In the contract requirement shells of this large caliber must, to be acceptable, go through plates without serious distortion or break. Both shells used met the requirements in a highly satisfactory manner, and the lot which they represent will be accepted. Three other representatives of the same group were tried later during the tests of the *Indiana's* barbette armor, to which allusion is made under another heading, and in these also the test was highly satisfactory. The trials demonstrated the superiority of both material and workmanship, and it is probable that the shell could have been fired again from the gun without much danger of increased distortion. The only distortion observable after measurement of the shells fired in the first test was about $\frac{1}{100}$ of an inch.

Spontaneous Combustion of Coal.—With respect to the ventilation of a cargo of coal, with the idea of removing inflammable gases, Professor Clowes, of Nottingham, England, has pointed out that this might itself be a source of danger. Four colliers were loaded with coal from the same seam, and by means of the same tips. Three were ventilated and proceeded to their journey to Aden. None of these reached the port, being all lost by the spontaneous firing of their cargoes. The fourth was not ventilated, and it reached Bombay in safety. There was little doubt that the air enclosed in the cargo was insufficient to give rise to dangerous heating, and that the introduction of additional air by ventilation enabled the heating to occur by supplying the requisite air. Coal which had heated in the air and begun to cool again was safe from risk of further heating; hence, storing coal in the air for a sufficient length of time before loading was a precaution which would be calculated to insure the safety of the cargo.

The following practical conclusions were submitted as deducible from the facts presented: 1. The danger of spontaneous firing of coal in large lumps is very slight; it is much greater with small coal, and greater still with dust. The increase of danger is due to the larger extent of surface exposed to the air in proportion to the mass of the coal. 2. Air-dried coal which contains more than 3 per cent. of moisture is dangerous; if it contains less the danger diminishes, as the amount of moisture is less. The moisture present in the coal is a measure of its absorptive power for air, and the most absorptive coal is the most dangerous. 3. The danger is somewhat increased by the presence of pyrites, in large quantity, not because this heats the coal to any appreciable extent, but because, when moistened, it swells—breaking up the coal and exposing a larger surface to the air. 4. Newly mined coal should be shielded from the air as much as possible, to prevent the chance of rapid heating, and for the same reason it is best not to stack it in large heaps, since these retain the heat. Ventilation of the coal often adds greatly to the risk of spontaneous firing. 5. All external sources of heat, such as steam pipes, boilers, and hot flues in the neighborhood of the coal, add very greatly to the risk of firing. Spontaneous heating becomes vastly more rapid when it is thus assisted by outside sources of heat.—*Coal Trade Journal.*

The Launching of a Big Ship.—Before actual construction begins, the builder of vessels which exceed the usual weight and dimensions has to decide upon the strength and solidity of the building berth, its direction relative to the water, and the amount of declivity of both the ground and the keel blocks. The problem in the case of these two big ships was quite serious for the Fairfield establishment. A vessel 620 ft. long and weighing approximately 9,000 tons, and having a very fine after-body, had to be launched stern foremost down an inclined plane into the water with a run of only 900 ft. from the end of the ways before she would be brought up by the opposite bank—that is, she had less than 300 ft. in excess of her own length in which to come to rest. The company first altered the angle at which vessels had been previously launched, so as to give the utmost possible scope within which to arrest the progress of the ship. The site of the berths was changed, although a disadvantage arose from the fact that the original ground for the new berths had not been consolidated by previously bearing the weight of heavy vessels. This drawback was overcome by driving extensive piling at the extreme outer end of the ways, gradually tapering up until single piling sufficed, the vessel being supported thence on cross logs sunk into the ground the usual distances apart. These alterations cost tens of thousands of dollars, but it is said that by this means, and without further changes, it will be possible for this company to undertake the construction of Atlantic steamers of dimensions fully covering the probable evolutions of the future. The efficiency of the scheme of consolidation may be held to be evidenced by the fact that when the last sighting of the keel of the *Campania* was taken, immediately prior to the launch, it was found that on any one part the deviation of the keel from the true level did not exceed a quarter of an inch. To insure that the way on these great steamers would not carry them to the opposite bank when afloat, the check and drag arrangements were of the heaviest and most carefully conceived description. They were so successful that they brought up the two vessels in about 60 and 100 ft. respectively from the end of the ways. Truly it is a great undertaking to lower a fabric of 7,000 to 9,000 tons 20 to 30 feet into the water, and the forethought and concern connected with the launching of such vessels begin almost with their inception.—*Engineering.*

Test of Armor Plates.—The test of armor plates held at the Indian Head proving grounds on July 11th were for acceptance and for premium, it having been stipulated that if the plates resisted penetration under a certain prescribed velocity, the makers should receive a premium of $30 a ton in addition to the contract price of $575 a ton. The first test was a 9-in. plate, 6 ft. and 4 in. wide and 9 ft. 7 in. long, a sample of the side-armor of the monitor *Monadnock.* It was nickel-steel, weighed 10 tons, and was made by the Carnegie Company of Pittsburgh. Three Holtzer projectiles, weighing 250 lbs. each, were fired against it from an 8-in. rifle, the muzzle being 58 ft. from the face of the target. The first projectile had a velocity of 1,400 ft. a second at the moment of impact, and penetrated the plate and oak backing to a depth of 11.7 in. The second projectile, with a striking velocity of 1,683 ft., went through the plate and 3 ft. of oak backing, and lost itself in the earth against which the butt was built. The third projectile had a velocity of 1,536 ft., and penetrated plate and backing to a depth of 14½ in. The plate well withstood the strain of the attack, no cracks being perceptible, and it fully met every requirement for acceptance, but the result of the second shot deprived the makers of any chance for the premium.

The test of the second plate was an exact duplicate of the first in its results. It was a sample of the curved plates for the barbette on the *Indiana,* made by the Bethlehem Company, and, like the first, of nickel steel. Its dimensions were 8 ft. 4 in. in height, 12 ft. 1 in. in length, and 17 in. thick, forming a mass weighing 31¼ tons. Like the *Monadnock* plate, it showed no cracks under the terrific strain to which it had been subjected.

Even more satisfactory than the showing made by the plates was that of the projectiles. The 8-in. shells were of the Holtzer conical pattern. Four of the shells that were recovered appeared wholly unchanged to the unpractised eye of the layman, and the gauge showed that they were disturbed to such a small degree that they might again be fired with the attachment of a new strip for rifling. Some idea of the force with which the shells struck the face of the plates may be gained from the fact that the energy of the last shot fired was equivalent to the force necessary to move a mass of 21,600 tons through 1 ft. of space.

A Snow Blockade on a French Railway.—The snow in France has, this winter, been exceptionally severe. In one night the whole of the country between Chartres and Pontgouin, a distance of 24 kilometers (nearly 15 miles), was covered with snow to a greater depth than has previously been known within the memory of living man, and whole trains were snowed up.

Immediate orders were given to the officials of all departments of the railway service, the working of which were affected by the block, to clear the lines, which work was effected in a week with marvelous rapidity. Under the supervision of the heads of the various departments, a staff of about 600 men brought from all parts of the line, assisted by troops requisitioned from the military authorities, one of the lines was cleared for traffic within a short time of the commencement of the block. The other road, which was more thickly embedded, took a much longer time to clear. The workmen shoveled away the snow which had accumulated in the cuttings, and thus facilitated the work of the six snow plows which completed the clearing of the line.

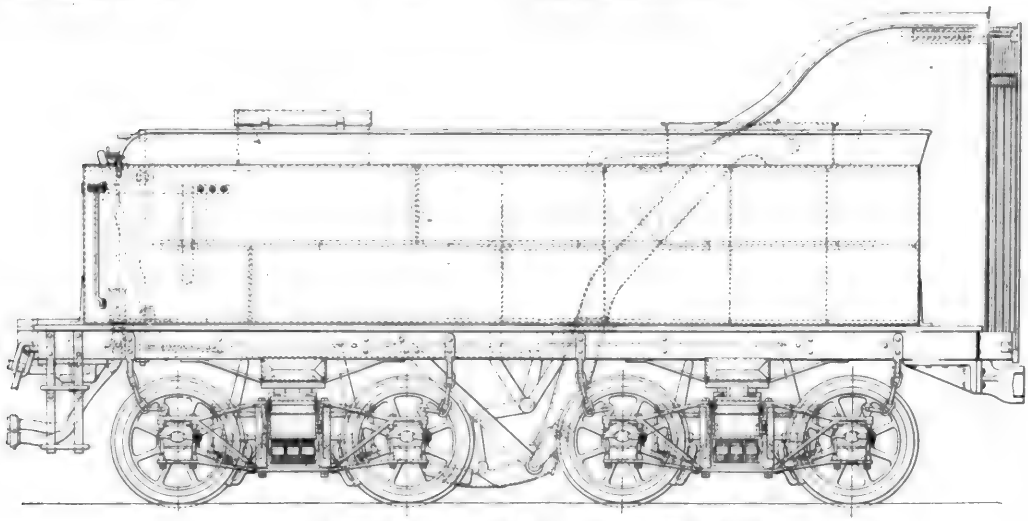
Frequently, however, in endeavoring to pierce banks of snow several kilometers in length and of from three to four meters (10 to 13 ft.) in depth, five of the snow plows coupled together were unsuccessful in the attempt; but in the end, thanks to the excellent organization, the clear-headedness of those in charge, and the steady work of the employés of all grades, two trains, which had been literally buried in the snow, were at length reached and disinterred. The passengers had, of course, left the train at the commencement of the snowstorm, seeing what was likely to occur, and had walked through the snow to a neighboring village.

One of these trains had left St. Nazaire on the Saturday evening, and did not arrive in Paris till the following Saturday, after being buried under the snow nearly 150 hours.

To remedy these accidents due to unforeseen causes, which might have serious consequences, and which cause delays so detrimental to the proper working of the traffic, it has been decided to erect on the windward side of the whole of the line between Chartres, Saint Aubin, Saint Luperal, Courville and Pontgouin, open palings at an angle of 45°. This palisading will be placed at 20 meters (about 65 ft.) from the cuttings, and will prevent the drifting of the snow on to the line, and it will so accumulate and form an insurmountable barrier and screen for the railway.

This system of horizontal palisades, termed *paraneiges* (snow screens), has been experimented upon near Chartres with complete success. Our engineers who have seen them in use in Russia, on the principal railways, were struck with their advantage, and they have recommended their adoption here.—*The Railway Herald.*

tated in the furnaces only partially consumed. In our issue for May 18, 1877, we described a system of coal-dust burning introduced by Mr. G. K. Stevenson, which had been experimentally tried in a Cornish boiler at Blackfriars. The fuel in the form of a very coarse powder was automatically mixed with the proper quantity of air, and propelled therewith into a fireclay retort some 8 ft. in length placed within the boiler flue, where ignition and combustion took place. Comparative results showed that under similar circumstances 8.3 lbs. of water were evaporated per pound of powdered coal against 6.5 lbs. per pound of lump coal. It is stated that during these experiments no smoke was produced, even when the air supplied was reduced to about the quantity necessary to chemically effect complete combustion. The principal drawback to the extended application of powdered fuel lies in the cost of pulverizing it, which materially adds to the price of the fuel, and in the difficulty of keeping the fuel suspended in the air current; but the system has formed the attractive subject of many experiments."



THE VESTIBULE TENDER EXHIBITED WITH THE PULLMAN TRAIN AT CHICAGO.

Powdered Coal and Smoke.—In our April issue we published an extract from *L'Electricien* regarding the working of a system of dust-fuel burning now being used in Germany. Referring to the same matter, the *Engineer* says: "Between 20 and 30 years ago this system attracted much attention, and more recently in America, under the name of the McCauley process, it has been pretty extensively adopted in the Pittsburgh district as a substitute for the gradually diminishing supplies of natural gas. At the present time pulverized coal driven into the furnace by a current of air is being experimentally tried for boiler firing in Berlin, with, it is stated, economical results, and an entire cessation of smoke production, but although it has been much pushed before the world by the newspapers, it does not appear that the Berlin system presents much novelty. John Bourne appears to have been the first, about the year 1857, to advocate the use of dust-fuel mixed with air and burned in furnaces like gas, by reducing the coal to dust and blowing it into a hot fire-brick-lined chamber for ignition and combustion. Mr. T. R. Crampton's investigations, commenced in 1868, are well known to all interested in the fuel problem. His experiments with dust-fuel were conducted in almost all kinds of furnaces, and in a puddling furnace constructed at the Royal Gun Factory, Woolwich, he was able to produce, with a cold-air supply, a temperature so high that wrought iron was easily melted, a result, be it remembered, absolutely impossible without regeneration, if the fuel had first been converted into Siemens' or Wilson's gas. Mr. Crampton, referring to boiler firing with dust-fuel, stated, in a paper read before the Iron and Steel Institute in 1873, that it was impossible to produce smoke, and this view has generally been corroborated by other investigators, including Mr. Isherwood, who carried out a series of experiments for the United States Government in 1876. No marked economy in the amount of fuel consumed was shown in the American experiments, but it seems probable that much of the dust escaped unburned, or was precipi-

VENTILATION.

Editor of the American Engineer and Railroad Journal:

In the construction of passenger cars great advance has been made in the interior fittings and decorations.

No end of money is expended in this direction. *Vide* the Pullman exhibit at the great Fair in Chicago. In point of artistic beauty of decoration and ornament, what can equal it?

In the all important matter of ventilation the appliances for this purpose are not equal to the first railroad cars. Why is this? Forty years ago the cars of the New York Central, Pennsylvania, and nearly all the roads had provision to get fresh air in at the frieze, and the spoiled air was drawn out through five or six 10-in. Emerson ventilators in the roof.

The idea of ventilating a car by one set of openings was looked on as absurd, as it is now by those who have given the subject any thought.

In a full passenger or sleeping-car the air becomes foul beyond expression.

Do the magnates that control such things know this? Perhaps not. They ride in their own special cars, and do not realize what the masses must endure. This is the most charitable construction we can put on this neglect of what is the most obvious requirement of a well-constructed car, whether for day or night travel.

To ventilate a car: 1. Fresh air must be admitted somewhere. 2. It must come in without cold drafts. If cold drafts are incidental to the plan of admission it will not do for the all-around purposes required. The aperture will be closed by the unlucky man who feels the draft. He does not think much about those who sit away in the middle of the car. 3. In winter, when the drafts are specially objectionable, some provision should be made to warm the air before its admission to the car. 4. The outlets for the spoiled air should be in the clearstory, and so arranged that cold drafts, cinders or smoke

will not come in. We simply state what are the requirements necessary to insure good ventilation, leaving it to the car-builders to carry out the details necessary to accomplish the purpose. We are perfectly sure that we are correct as to the theory, and surely there must be engineering ability enough in the United States to produce something better than the unsatisfactory methods now in vogue. We call upon all car-builders and officials to wake up and try what can be done. We have lived long enough under the glamour of splendid cabinet, upholstery, gold and brass work, and the people, while not objecting to the glamour, etc., demand the addition of a little fresh air. C.

Our correspondent calls attention to the illusion which prevails very generally, which is that an apartment can be ventilated satisfactorily by simply providing openings for the escape of air. Simple as the idea may seem, a surgical operation would be required in many cases to make people understand that, in order to get fresh air into a car or room, there must be provision made for it to enter, and for an adequate supply at all times. There is very little difficulty in exhausting bad air, the great trouble in ventilation is the admission of fresh air; Nevertheless, in nine-tenths of the efforts which are made to ventilate cars and houses no attention at all is given to the means of supplying pure air.—EDITOR AMERICAN ENGINEER.

OBTAINING SPECIFIC GRAVITY WITH A PLATFORM SCALE.

By JOHN F. WARD.

ENGINEERS and others sometimes find themselves in situations where they wish to find, without delay, the specific gravity of some material found in the progress of the work in hand, and the apparatus for making the usual test is perhaps hundreds of miles away.

Fortunately it is usual, or at least frequent, in even the most remote parts of this country, to find at any reasonably well fitted out ranch or mining or construction camp some sort of a platform scale, which if properly used will find the specific gravity of a specimen of 30 lbs. weight or upward as accurately as is required for most purposes, and the larger the specimen the greater the accuracy.

The way of getting at the result is to weigh the specimen in the air, calling the weight W, then put a tub or other vessel on the scale, and putting in enough water to cover the specimen to be tested, without overflowing, take the united weight of the tub and water. Now suspend the specimen in the water from some point independent of the scale and tub in such a way that it is completely covered by water and does not touch the tub. Note the increase in weight caused by the immersion of the specimen in the water. This is the weight of the volume of water displacedtby the specimen, and may be called D.

Divide the weight W of the specimen by the displacement weight D, and you have the specific gravity, or in the shape of a formula $\frac{W}{D}$ = specific gravity.

A VESTIBULE TENDER.

IN our last issue we presented an illustration taken from the photograph of the vestibule train exhibited by the Pullman Company at Chicago, showing the engine *Columbus* with vestibule tender, which was built at the Baldwin Locomotive Works. We now present a side elevation of the tender on an enlarged scale, showing the method by which the vestibule is attached and the general outlines of the construction of the tender. The tank and coal-box with the water scoop remain unchanged from the usual form adopted in regular work. The only change which has been made on the tender at all is the addition of the Pullman vestibule, as it is shown. This consists of a vestibule bracket, as it might be called, corresponding to the end of a car, and rising up flush from the back end sill of the tender, just as the ordinary face of the vestible rises from the end of the platform of a passenger car. The vestibuling arrangement is then fastened directly to this, so that the action between the tender and the front car is identically the same as that between any two cars on the train. While this vestibule attachment will undoubtedly be serviceable in the case of train robberies, as was suggested in our last issue, on Western roads, there is a very strong sentiment in favor of the vestibule attachment for protecting cars and trains from ordinary accidents and the prevention of telescoping.

About a year and a half ago a certain New England road had a train equipped with the vestibule attachments. The superintendent of motive power was very enthusiastic over the results, which he obtained in steady riding, and was positive that increased safety would result. Speaking with his general manager on the subject, he made use of the expression, which he confessed seemed an exaggeration, in saying that if he could have his way he would put a vestibule even on the tender, hardly realizing that such a thing would be actually an accomplished fact in the near future. There is very little to be said in regard to the mechanical construction of this particular arrangement, inasmuch as it is clearly shown by the engraving, but it is particularly interesting from the fact that while it is the first, it will probably not be the last one of these attachments to be used.

TECHNICAL IMPORTANCE OF ALUMINIUM AND ITS FUTURE APPLICATIONS.

THE general effect of aluminium when used to alloy with other metals is the increase of their ductility when small quantities are added, and of their ultimate strength when the amount employed is larger. A certain mean quantity therefore gives the most favorable results in both respects. The aluminium-bronzes are the most generally useful alloys; in the following table are some figures given by Tetmajer for cast specimens:

Commercial name.	Percentage of aluminium.	Tensile strength.	Extension on 1 dm. (3.9 in.)
		Lbs. per sq. in.	Per cent.
Gold-bronze........	5.5	59,900	[illegible]
Steel-bronze........	8.5	63,650	52
Acid-bronze........	10	80,800	...
—	11.5	101,800	0.2

All these bronzes are almost unaltered in air. The 8.5-per cent. alloy is that in which the increased tensile strength and the augmented extension are combined to the greatest advantage. The 11.5-per cent. alloy represents the limit at which the addition of aluminium renders the product brittle. The so-called "steel bronze," when cast, has an elastic limit of only 7,600–10,180 lbs. per square inch, but this can be raised by working to 30,500 lbs. with an ultimate strength of 76,000 lbs. and an extension of 35 per cent. This alloy has been used by the Maschinenbau-Actiengesellschaft in Nüremberg for eccentric straps, bearings, gear-wheels and similar purposes. Nails and screws have been made from it, and it has been used for the couplings of the tubes connecting steam-heated railway coaches. Bearings made from the 5-per cent. bronze wear better than those of gun metal containing 10 per cent. of tin. Hard rolled sheet with a high content of aluminium has been used for springs in such things as arc lamps. Tetmajer has also tested certain cast specimens of aluminium brass. The brass used contained 67 per cent. of copper and 33 per cent. of zinc. The results show that copper can bear a much larger percentage of aluminium before becoming brittle than brass. This is also true as regards different qualities of brass, the permissible quantity of aluminium increasing with the percentage of copper.

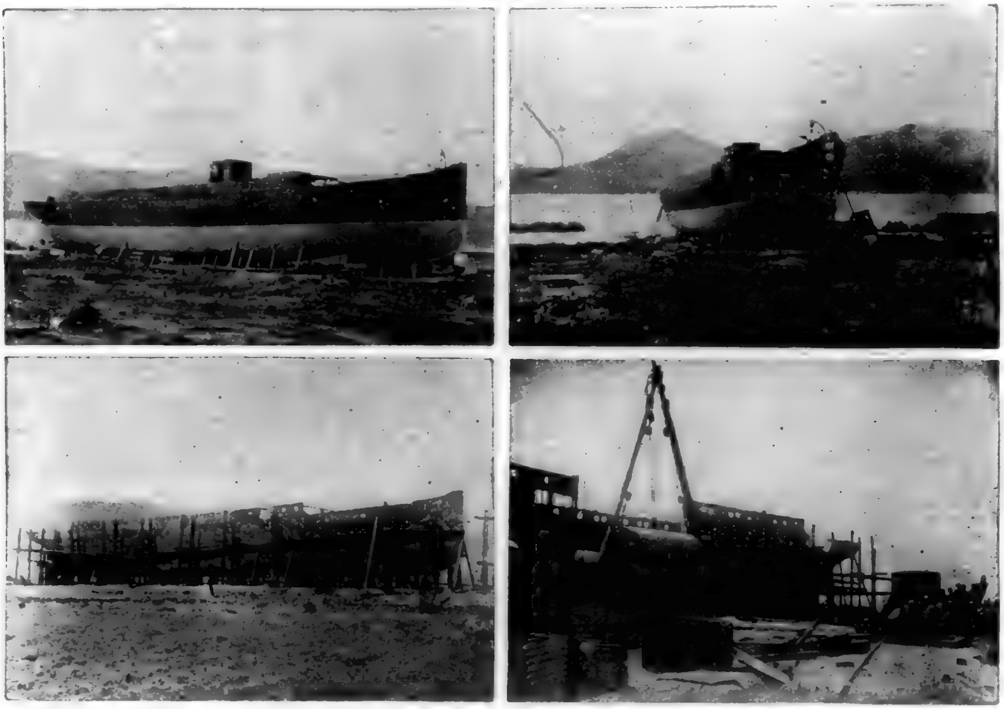
Aluminium lends itself to the production of decorative effects, as it may be given a dead white surface by the action of caustic soda, and gray tones can be produced by similar means. It may be readily spun, and all kinds of hollow goods prepared from sheet metal without a joint. The tensile strength of cast aluminium is about 12,700 to 15,300 lbs. per square inch, and it has an extension of only 3 per cent. Its strength may be raised by working, and notably by rolling. It is annealed by heating and rapid cooling.

Attempts have been made to raise the strength of aluminium by the addition of small quantities of other metals. The following are the results with copper: *Tensile strength* (lbs. per square inch), 2.7 per cent. of copper added, cast, 20,500; cold rolled, 38,200; annealed, rolled, 25,500; 6 per cent. of copper added, cast, 15,300; cold rolled, 42,000; annealed, rolled, 25,500; 2.5 per cent. of copper and 2.5 per cent. of cadmium added, cast, 24,200. *Extension on 1 dm.* (3.9 in.) per cent., 2.7 per cent. of copper added, cast, 18.5; cold rolled, 3; annealed, rolled, 19.5; 6 per cent. of copper added, cast, 5; cold rolled, 10 to 12; annealed, rolled, 10 to 12; 2.5 per cent. of copper and 2.5 per cent. of cadmium added, cast, 18. When 10 per cent. of copper is used the alloy is brittle in the cast state, but loses its brittleness on working, and is fairly hard, while its

specific gravity is not raised much above that of pure aluminium, being 2.9.

Aluminium is troublesome to cast, forming blow-holes freely, a defect which Coehn has attempted to remedy by the addition of sodium. The electric conductivity of aluminium is only 59 per cent. of that of copper, in spite of which it might be used for field-telegraph purposes on account of the saving of weight. The conductivity of aluminium-bronze is too low to allow of its use for telegraph or telephone lines, for which purposes it is otherwise well suited on account of its high tensile strength. Pure aluminium, when cast, shrinks about 1.8 to 2 per cent.; the shrinkage is diminished by the addition of 8 per cent. of copper. The loss by oxidation on remelting is about 2 to 6 per cent. The problem of soldering aluminium satisfactorily is not yet completely solved. Taking the present price of aluminium at 3) cents per lb., it is volume for volume 164 per cent. cheaper than nickel, 11 per cent. cheaper than tin, and only 20 per cent. dearer than copper.

The Oesterreichische Alpine Montangesellschaft uses a 10-per cent. ferro-aluminium in quantities of 0.25 to 0.5 per cent. as for the sheathing of ships. Nemetz has made many experiments on the suitability of aluminium for the beams of analytical balances. Rolled aluminium sheet has long been used with success, but these later experiments were with the cast metal. Pure aluminium was too weak, and the alloys containing copper had a tendency to form cracks during stamping. The best results were obtained with an alloy of aluminium containing 3 per cent. of fine silver and 2 per cent. of chemically pure copper, the casting, after being diminished in cross section about 0.2 to 0.3 millimeter by pressure, being hard and springy, free from cracks, and showing no tendency to flexure until severely overloaded. The surface could be polished with very fine emery paper and oil, but with other polishing agents a rough porous appearance was produced, although the metal was really free from pores. The alloy retains its condition better than ordinary gilded beams, even after having been in use for years. When aluminium is cast a second time a certain quantity of fresh metal must be added to avoid the formation of blow-holes. Aluminium can be made into tubes by the Mannesmann process.



CONSTRUCTION OF THE TWIN-SCREW STEAMER "COYA" ON LAKE TITICACA.

an addition to Siemens-Martin steel of special quality. The action is a double one. The steel bath is quieter, and blow-holes are almost wholly removed. The addition of ferro-aluminium is not found necessary for crucible cast steel. The addition of aluminium has also been practised by the Witkowitzer Bergbau- und Eisenhüttengewerkschaft for producing sound castings, with success. The additional cost is quite trifling. The attempt to use aluminium as a substitute for ferro-manganese in the converter or in an open-hearth furnace is rendered nugatory by the lightness of the metal causing it to float on the surface of the bath, and there burn uselessly. If added to the metal in the ladle the surface becomes honeycombed in an inexplicable manner, so that the use of aluminium is restricted to the removal of comparatively small evolutions of gas in place of silicon, which has long been used for quieting the metal and getting sound castings.

As regards the prevention of blow holes in copper, phosphorus appears better suited than aluminium. It is stated that according to the experience of the French Navy aluminium-brass containing 2 per cent. of aluminium has been found to resist the action of sea water, and to be the most suitable metal

The future applications of aluminium depend mainly on its price. There appears reason to think that the actual cost of manufacture cannot by the present processes fall much below 15 cents per lb. The author compares the cost of its production with that of iron. He finds that the price of the raw material is eight times as great as that of iron for a given content of the metal. He calculates that the capital expenditure necessary per ton of aluminium is about 56 times as large as that requisite for an iron works. The cost of energy, even allowing the use of water-power, is about three times what it would be for iron. In addition to this an expenditure of 1.5 cents per lb. of aluminium is necessary for the carbon electrodes used. From these figures it results that aluminium must be 6.7 times as dear as iron without reckoning the cost of the electrodes—that is, taking pig-iron at only 2 cents per lb., the manufacturing cost of aluminium would be 13.4 cents per lb., or with the addition of the 1.5 cents for electrodes mentioned above, 14.9 cents.

Progress of the Aluminium Industry.—A comparison is drawn between three 10-ton displacement sailing yachts built of wood, steel and aluminium, respectively. For the same strength the

aluminium yacht will have less than half the weight of the others; this will mean a larger amount of ballast, in order that the displacement may be the same, and a corresponding lowering of the center of gravity. Thus, in the wooden vessel the center of gravity will be 1.4 ft.; in the steel vessel, 1.5 ft.; and in the aluminium vessel, 2.1 ft. below the water-line. The stability of a vessel is greater the lower the center of gravity, and the sail area is proportional to the stability. For the three yachts in question the sail areas will be in the ratio 1 : 1.06 : 1.35, and as the speed is proportional to the square root of the sail area, this value for the three will be in the ratio 1 : 1.03 : 1.16. For the same displacement, then, the aluminium yacht is much the fastest. The ratio of cost may be approximately stated as 1 : 1 : 1.8, but from this last figure must be deducted the value which the worn-out hulk of the aluminium yacht will still possess.

Great advantage as regards weight is claimed for the use of aluminium framework for the windows of railway coaches; it should also be employed for parts of sewing-machines. An alloy of aluminium with 17 per cent. of copper is recommended for slide-valves. For glue, gelatin and wax boiling and melting pots, aluminium has the advantage that it does not discolor the products, as do iron and copper, by forming colored sulphides with the sulphur in the glue, etc. An alloy of aluminium with 6 per cent. of copper is employed for watch-cases in the Swiss watch industry. Lithographic stones and composing-sticks of aluminium have been patented. A large number of small articles, such as penholders, billiard cues, etc., are made of aluminium by the Mannesmann method of tube rolling.

Aluminium-bronze is being extensively used for marine and torpedo work; it has a lower specific gravity (7.7) than any other non-rusting metal (phosphor-bronze = 8.9). The "double bronze" wire for telephonic use is an aluminium core with a copper sheathing, its breaking strain is 96,700 lbs. per square inch, and its conductivity is 69 per cent. of that of copper, which is better than silicon-bronze of the same strength. The 5-per cent. bronze is well fitted for the ignition tubes of gas motors on account of its resistance to oxidation at high temperatures; according to H. Schiff it is 17.6 times less oxidizable than copper, when heated in oxygen, apparently because the layer of oxide first formed does not scale, and thus protects the metal beneath. The 12-per cent. bronze has been used for some time for the needles of percussion caps.

With respect to the addition of aluminium to steel, J. O. Arnold states that he has observed a temperature rise of more than 100° immediately after the addition, and is of opinion that the freedom of the casting from blow-holes is due in great measure to the reduction of dissolved carbon monoxide by the aluminium. He has passed this gas over red-hot aluminium and obtained alumina and carbon, and by passing carbon-monoxide through a molten steel containing aluminium he has raised the carbon content from 0.30 to 0.51 per cent. The addition of aluminium is recommended for all castings which are to stand pressure, and is effected as follows: The aluminium ingots are heated in a small ladle and some iron allowed to flow on to them; these are mixed until the mixture begins to solidify, whereupon the mass of the iron is run into the casting ladle and the aluminium alloy immediately poured in; 0.2 lbs. of aluminium per 100 lbs. of iron are recommended. The casting is not made immediately after the addition of the ferro-aluminium, but as soon as a thin scum makes its appearance on the surface of the metal, which by this time will have cooled to orange-yellow. The reason for thus waiting is probably because the contraction of iron containing aluminium is greater than that of ordinary cast iron, so that the more nearly the temperature approximates to the solidifying point when the casting is made, the better this will be.—*Iron.*

TWIN-SCREW STEAMER FOR LAKE TITICACA.

By J. G. B.

The accompanying engravings represent the work in progress on the reconstruction, on the lake shore, of the new twin-screw steamer *Coya.*

As some of your readers may not be very well informed about Lake Titicaca, perhaps a few particulars will not be out of place. This beautiful lake is 12,500 ft. above sea level, and the highest navigable lake in the world. It forms part of the boundary between the south of Peru and Bolivia.

Puno, the chief Peruvian port, is connected with the coast by a railroad, the distance being 325 miles. The managers of the railroad also control the navigation on the lake.

The latter is about 120 miles long, and varies from 35 to 45 in width, fresh water.

Two small steamers, about 100 ft. long, have been plying the waters of this historic lake for the past 20 years, but the need of a new and larger vessel has long been felt, as the "imported" freight, merchandise, etc., for Bolivia has gradually been increasing, likewise "exported" freight—silver, copper, and lead ores, also quinine bark, coca, etc. The want has at last been supplied in the twin-screw (steel) steamer *Coya*, whose dimensions, etc., are as follows:

Length between perpendiculars, 170 ft.; breadth moulded, 26 ft.; depth moulded, 12 ft., and is guaranteed to carry 260 tons on a draft not exceeding 7 ft.

The hull was constructed by Messrs. William Denny & Bros., of Dumbarton, Scotland, and the machinery by Messrs. Denny & Co. of the same town.

After being erected in the yard, she was taken to pieces and shipped to Mollendo, Peru, to be rebuilt on the lake.

The vessel has been constructed of the very lightest possible scantling consistent with longitudinal strength, and has four water-tight bulkheads carried up to main deck.

She is a flush-decked steamer, with a very long bridge amidships; this is given up almost entirely to the accommodation of first-class passengers, provision being made for 45.

A large dining saloon seating 35 is to be fitted near the fore end of the bridge, and will be handsomely panelled, painted, and decorated. State-rooms, large and airy, and a separate and comfortable cabin is provided for the use of ladies.

She will be rigged as a fore-and-aft schooner. *Machinery* consists of a pair of direct-acting, surface-condensing, compound twin screw engines, arranged so that each propeller may be worked independently of the other; two navy boilers 16 ft. 6 in. long by 8 ft. diameter, and having in all four furnaces 3 ft. inside diameter; working pressure, 110 lbs.; two cylinders, one high pressure and one low pressure. High-pressure cylinder to work the starboard engine and the low-pressure cylinder the port engine. High-pressure cylinder, 20 in. diameter; low-pressure cylinder, 38 in.; stroke, 24 in.

Propellers built up three-bladed, shifting blade, both to work outward when going ahead.

Tripping Gear.—A large balanced fly-wheel will be fitted on each line of shafting, on crank-shaft coupling. Each fly-wheel has notches cut in the rim so that, should the engine be on the dead center, it may be assisted by a hand-lever engaging in them. This hand-lever to be common to both engines, and to be worked from starting platform.

The vessel has been specially built with a light draft, as, owing to the shallowness of the water, entering and leaving most of the ports is somewhat difficult. Nevertheless in some parts the lake has a depth of at least 1,000 ft.

The speed guaranteed for the trial trip to be not less than 10 knots.

AMERICAN AND ENGLISH LOCOMOTIVES.

(*Continued from page 321.*)

Some years ago one of the distinctive features of American locomotives was that we used a truck and our English brethren did not. Of late, however, they have conformed to our practice, and now the use of the truck is very common under European locomotives. It is not worth while to spend any time in unprofitable discussion whether the use of the truck under locomotives originated here or in England. With the front axles of ordinary vehicles connected to their bodies with king-bolts, it does not seem as though any very great amount of invention was required either here or in England to connect a pair of axles to a locomotive in the same way. The points of interest in the present comparison which we are making will be the features in which the two trucks differ in construction.

The following is the brief specification of the American truck:

ENGINE TRUCK.

With square wrought-iron frame, cast-iron pedestals, and center-bearing suitable for rigid center, with approved arrangement for equalizing beams and springs.

WHEELS.

Four Krupp steel-tired spoke wheels, tires held by retaining rings.

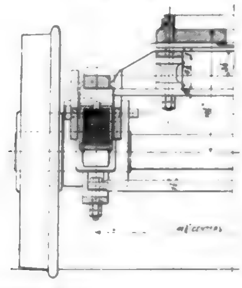
AXLES.

Of hammered iron, with inside journals 6 in. in diameter and 10 ins. long.

The specifications for the English truck or "bogie" are as follows:

BOGIE.

The bogie is to be made of the form and to the dimensions shown on drawing. The wheels are to be placed 7 ft. 6 in. apart, center to center. The frame plates are to be of the same quality as those specified for the main frames, 1 in. thick and placed 2 ft. 7¾ in. apart. The axle-box guides are to be of the very best cast steel, of approved make, free from honeycomb and all other defects. The flanges are to be planed all over and fitted to template. They are to be fixed to the frame by bolts ⅞ in. in diameter, accurately turned, and driven tight into the holes. The frames are to be firmly secured to a cast-steel stay with ¾-in. rivets, zigzag pitch. Great care must be taken that the frames, when put together, are perfectly parallel and at right angles with the steel stay. The cast steel cross-slide is to be planed on its rubbing surfaces and bored out to receive the bogie pin. Each side-controlling spring is to be laminated, and is to consist of 16 plates 2½ in. wide and $\frac{5}{16}$ in. thick. They are to be made of the very best quality of spring steel manufactured from Swedish bar iron. Each spring must be thoroughly tested before being put into its place by being weighted with two tons, and on the removal of this weight it must resume its original form. The top plate of each spring must be stamped with the maker's name and date of manufacture and be to the same specification as the driving and trailing springs. The plates are to be properly fitted and tempered, and are to be prevented from shifting side or end ways by nibs stamped upon them. The buckles are to be sound forgings, and are to fit the springs accurately, and are to be well secured by a short wrought-iron pin driven while hot through a hole in the top of the buckle, and with a hole in the top plate. Through the center of the casting form-



CROSS-SECTION OF AMERICAN EXPRESS PASSENGER LOCOMOTIVE TRUCK.

ing the bogie-pin a wrought-iron pin 3 in. in diameter is to pass, fitted at the bottom end with a nut and washer; the hole in the stay is to be elongated to allow for the lateral motion of the cross-slide. Each spring cradle is to be made of two Yorkshire iron plates 6 in. deep and 1¼ in. thick, with cast-iron distance pieces riveted between them at each end; these cast-iron pieces are to be provided with means of lubrication, and are to be shaped to rest on the saddles formed on the top of the axle boxes. The springs are to be coupled to the beams by hooks as shown; the pins through the hooks are to be of steel, and the eyes of the hooks are to be case hardened. The brackets holding the springs are to be of Yorkshire iron and are to be bolted to the frames with 1-in. turned bolts driven in a tight fit. The whole of the work is to be of the best description, and the bogie, when finished, must be perfectly square and free from cross windings and according to drawings.

BOGIE WHEEL CENTERS.

The bogie wheel centers are to be of good sound cast steel of approved make; quality, manufacture and tests same as specified for driving the trailing-wheel centers. Each wheel center to be turned to a diameter of 3 ft. 8½ in., the rims are to be 4¾ in. broad, 2½ in. thick at center, to have 10 spokes 1¾ in. thick at the boss and 4 in. deep, and at the rims 1½ in. thick and 3¼ in. deep. The bosses are to be bored out parallel to a diameter of 7 in., and are to be 1 ft. in diameter. The wheel centers must be bored and turned strictly to template, so that they shall be exactly alike. Each wheel center must be forced on the axle by a hydraulic pressure of not less than 70 tons. The wheel centers are to be fixed to the axles without keys.

BOGIE AXLE BOX.

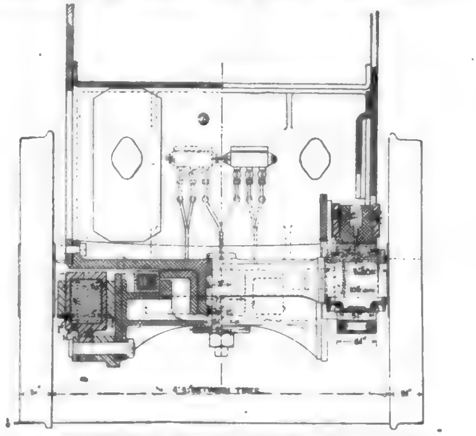
The bogie axle box to be of the best gun-metal, keeps to be of cast iron, to have bearing surfaces and provision for lubrication, as shown on drawing. The axle-box bearings to be $\frac{1}{16}$ in. shorter than the axle journal to give clearance.

BOGIE SPRINGS.

The material, workmanship, method of construction and testing of the bogie springs must be the same as for the driving and trailing springs. The bogie springs are to consist of 14 plates ½ in. thick, 5 in. broad, to a span of 3 ft. 11¾ in.

It will be seen that a noticeable difference in the two trucks is the fact that the center of the English bogie has lateral motion, whereas the American truck has not. This, of course, brings up the much-disputed question of whether there is any advantage in having side-motion trucks on engines of the general plan here illustrated.

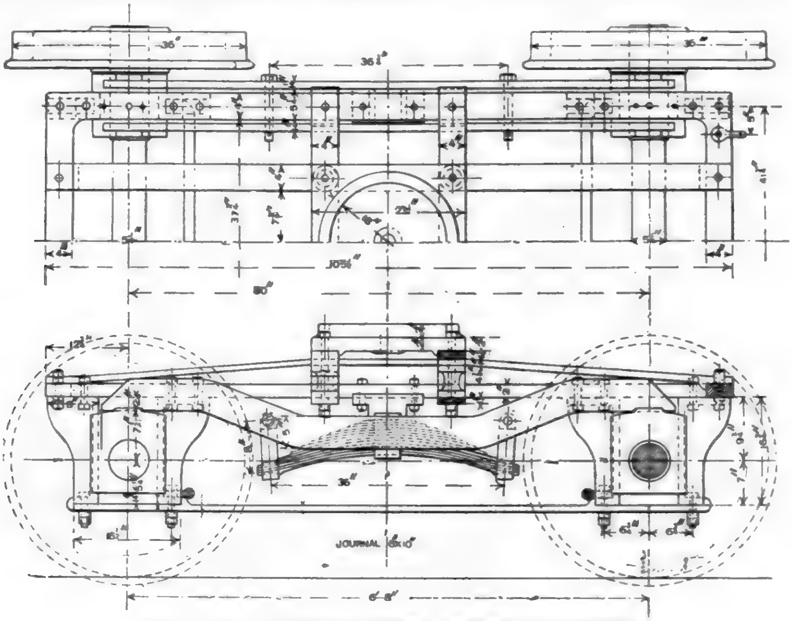
It is, of course, true that if all the driving-wheels are flanged, that an engine with a lateral motion truck can run around or through curves and turnouts of shorter radius than is possible with a rigid center truck. On some of our older roads, such as the Baltimore & Ohio, and Boston & Albany, the front or main pair of driving-wheels on the American type of engine were formerly, and may be yet, made without flanges, in order to permit the engines to run over some of the very short curves in use on those lines. On curves of ordinary radius neither of these expedients is required; and it is claimed that with our American "swing trucks," on which the weight of the engine is suspended by pendulous links, the "nosing" or lateral movement of the front end of the engine is increased, and that lateral motion is not required unless the curves and sidings are unreasonably short. In the arrangement shown in the English truck which we illustrated it will



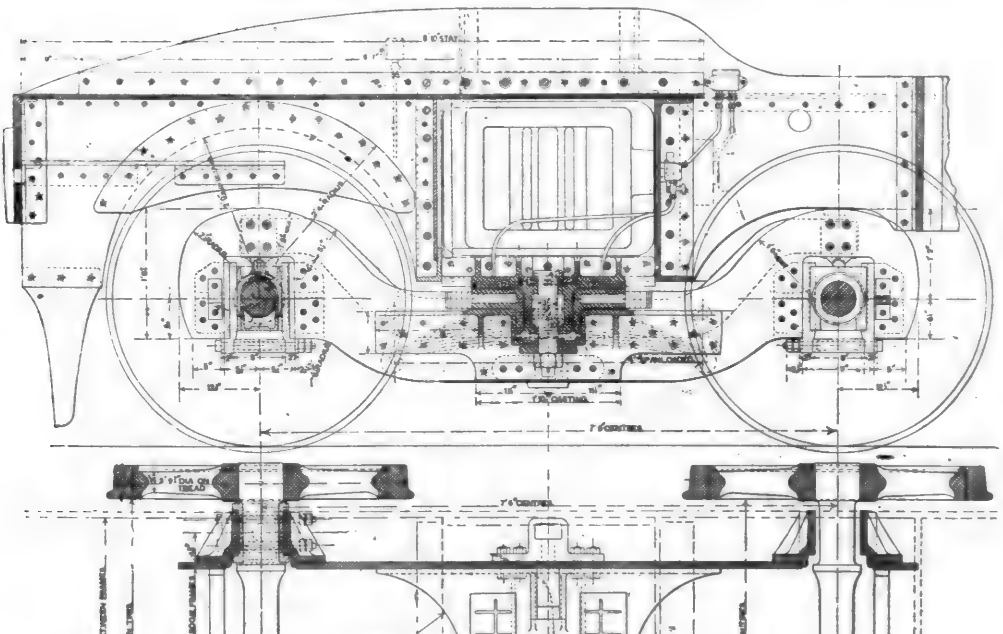
CROSS SECTION OF ENGLISH EXPRESS PASSENGER LOCOMOTIVE TRUCK.

be seen that the weight of the engine is supported on a laterally sliding plate or block, the movement of which is resisted by half elliptic springs on each side. Therefore before the truck can move in relation to the engine it must overcome the friction of the sliding plate and also the tension of one of the springs. The amount of this tension may be so adjusted that under any ordinary conditions of working the truck will have no lateral motion, but would only move when any abnormal lateral strain is brought on it such as would occur in running into turnouts or curves of very short radius. Practically, then, Mr. Adams's truck, for all ordinary conditions of working, has a rigid center, but in emergencies it can move laterally. If the alignment of any road is such as to compel the running of engines over places which will produce abnormal lateral strains on the flanges of the driving-wheels by reason of the shortness of the radii of curvature, then the expedient employed on the English truck would seem to be a very good one. It is not required on the New York Central & Hudson River Railroad, and on nearly all our lines it is found to be more satisfactory to lay the track to suit the engines rather than to build engines to run on curves which are in many ways objectionable.

In the construction of the truck frames there is a very marked difference. The main part of the English frame consists of two steel plates 1 in. thick and 14 in. wide riveted to a massive casting which supports the front end of the engine. The main part of the frame of the American truck consists of a bar whose section is 2 × 4 in., which is welded together so as to form a rectangular frame 8 ft. 9½ in. long × 3 ft. 9¼ in.



TRUCK FOR AMERICAN EXPRESS PASSENGER LOCOMOTIVE.



TRUCK FOR ENGLISH EXPRESS PASSENGER LOCOMOTIVE.

wide. The center-plate, which carries the weight of the engine, is attached to this frame and supported by a system of trussing composed of bars of 4 × 1 and 1½ in. section.

The "axle-box guides"—or jaws, as we call them—of the English bogie are bolted to the sides of the steel plates, whereas on the American truck they are bolted to the under side of the rectangular frame. The spring of the latter bears against the under side of the rectangular frame, or, perhaps, it should be said that the frame rests on top of the springs. On the English engine the springs are supported by castings bolted or riveted to the sides of the plate frames. It is thought that to make so important a member as a truck frame to bear directly on top of the springs and axle-box guides is a much more mechanical method of construction than it is to attach the parts to the sides of the frames, and thus subject them and their fastenings to very severe cross strains.

An inspection of the engravings will also show that all that there is to resist the lateral pressure of the English engine against or toward the rails is the stiffness of the two 1 in. plates of the truck frame. It is very questionable whether these would have stiffness enough to prevent them from springing or bending if they were used on some of our rough and crooked roads.

The truck wheels of the English engine are 3 ft. 9½ in., whereas those of the other engine are 3 ft. only in diameter. In order to be able to use as large a wheel under the American engine, it would be necessary to use a different form of guides and cross-head, as wheels as large as those used by Mr. Adams would come in contact with the guide bars if made as they are in Mr. Buchanan's machine. Large wheels are of course an advantage for fast running.

The journal bearings are 10 × 5½ in. and 10 × 6 in. respectively; the American engine is the heaviest and has the largest journals. Probably if the difference in weight and size of wheels is taken into account the journals of the English truck are relatively the largest.

Of the wheels perhaps little need be said, as those used under Mr. Buchanan's engine were made by Krupp, and Mr. Adams uses wrought-iron wheel centers. It is, therefore, hardly a question of European and American practice. It may be said, however, that it is only very lately that the merits of wrought-iron spoke wheels have commenced to be recognized in this country.

Reference to the drawings will show that the truck springs of the one truck are 4 ft. and those of the other 3 ft. long, the foreign springs being the longer. The difference is in favor of English practice.

It will also be observed that the bearing surfaces for the support of the weight of the engine on the center of the truck are very large on the English truck. It has always been considered that it is important that a truck should have capacity for lateral adjustment to inequalities of the track. This is perhaps important on unballasted and very rough roads, but is much less so as the permanent way of lines is improved. With fast speeds, amplude of bearing surface which gives stability is then more important than latter adjustability.

PATENALL'S IMPROVED SYKES' SYSTEM OF BLOCK SIGNALS.

BY THE JOHNSON RAILROAD SIGNAL COMPANY, RAHWAY, N. J.

(Concluded.)

IV.

IN reading the following explanation of the operation of the signal instrument whose construction was described and illustrated in our article last month, the reader should have before him the engravings published in that number of the AMERICAN ENGINEER.

Fig. 32, herewith, is a diagrammatic plan similar to figs. 1, 2, 3 and 4, published with our first article in the May number of this paper, and shows a double-track road and three stations. In fig. 32 some of the parts of the signal instruments and their electric connections are indicated, with details omitted so as to make their relation to each other clear. The stations are designated as A, B and C, as they were in figs. 1, 2, 3 and 4.

The direction of the movement of the west-bound and east-bound trains is also indicated, as in the figures referred to. To simplify the description as much as possible, only those signal instruments and the wire connections which refer to the west-bound track are represented in the plan, and will be described now. It should be understood, however, that for an ordinary double-track line the instruments and systems of wire, with the exception of line wires, are duplicated for the other track, the construction and operation of the instruments and their connections being the same for each.

In order to make the operation of these appliances clear, it will be assumed, as it was with reference to our preliminary description of the block system, that we have a train T, fig. 32, at station A, and that A's signal is raised to indicate "danger," and that he has asked B by telegraph or ringing a bell to unlock his, A's, signal, so that he may be able to lower it and admit the train to section 2. If this section is clear, B's indicator at o', fig. 21, would show that there was no train on from A, and his signal instrument would be in the condition shown by fig. 20—that is, the operating bar S' S would be pushed in to the extreme limit of its movement, the vertical sliding-bar L L, which carries the arm E, would be raised up. During the upward movement of E the nose l'' would have engaged with the nose p'' on the sliding plate j', and the top of this plate, engaging with a shoulder on the plate I, would have carried the latter with it. The slots in those two plates (see fig. 28) would thus be brought opposite to the end of the plunger P, as also shown in fig. 20. Consequently the plunger may then be pressed inward, and if it is it will come in contact with and move the swinging arm E, as shown in fig. 27, the movement of which would bring the insulating block m' against the strip N, which carries the pin n'. This produces an electrical contact between n' and Q.

By means of suitable wire connections—shown in fig. 32—this movement will establish a complete electrical circuit from a battery Z, at station B, to station A, and through A's electro-magnet M (shown in figs. 20 and 32). The effect of B's plunging is to pass a current of electricity through A's magnet, which will attract its armature f', fig. 20, and raise the latch g. This will unlock A's operating bar S' S and permit him to pull it outward. This will unlock his signal lever and allow him to lower his signal, and thus admit the train to section 2.

In fig. 27 it may be seen that when the plunger P is pushed inward against the arm E that the elongated slot in the plate j' permits it to fall, so that its nose p'' passes that of l'' on the arm E. When the plunger is withdrawn both plates can fall into the position shown in this figure. In its descent the plate I carries with it the indicator B', which brings the inscription "TRAIN ON" behind the slot o', as shown in fig. 21, so that B's indicator then reads, "TRAIN ON FROM A," which means that A has or can now admit a train to section 2. It will also be noticed from fig. 24 that when the plunger P is withdrawn and the plates I and j' have fallen into the position in which they are shown in this figure, that it will then be impossible to push the plunger inward again until these plates have been raised up; in other words, a signalman, having once plunged to the station behind him to admit a train, he cannot do it a second time until his plunger is released by raising up the plates I and j'. The means of doing this will be explained presently.

Let it be supposed now that the train is on section 2, as shown at T', and is approaching station B, and that B's signal is raised to indicate "DANGER," and that the sliding or operating bar S' S of his signal instrument, fig. 20, is then in the position in which it is shown in the figure last referred to—that is, it is pushed inward as far as its limits of movement will permit. His signal lever L, shown in fig. 5, would then be locked. Before the operator at B can lower his signal to indicate that the line in section 3 is "CLEAR," and thus allow the approaching train to pass his station, his signal lever must be unlocked. It has been explained that it is locked by means of a latch k, shown in figs. 10–17. This latch is released by raising the rod C C', fig. 9, which is connected to the rocker R, fig. 20. To raise this latch the horizontal sliding or operating bar S' S, of the signal instrument, fig. 20, must be moved outward to the extreme limit of its movement, or into the position in which it is shown in fig. 25. This movement will bring the stud e' in contact with the shoulder e. This turns the rocker about its center d and thus lifts the rod C' and the releasing latch k, shown in figs. 10–17; but when the parts of the signal instrument are in the condition shown in fig. 20, the bar S' S is locked by the latch g, which engages in the elongated slot b', and the bar can only be moved outward a distance permitted by the length of that slot. To disengage the latch the magnet M must be energized so as to attract and lift the armature f' and the latch with it.

It has been explained that the magnet M is electrically connected by a wire 3 with the plate P. The plate P' is connected by another wire 1 with a line wire leading from station B to station C. As plates P and P'' are separated by non-conducting material when the parts are in the position in which they are shown in fig. 20, there is no electrical connection between them. Consequently it is impossible to send a current of electricity from station C through the line wire to the magnet D in B's signal instrument. In order to establish electric communication between his magnet M and station C, the signalman at B pulls out the knob H and the operating bar S' S'

as far as the slot b' and latch g will permit. This will bring the lug c between the two abutments a a'. At the same time the movement of the stud o'' acting on the bell crank o'' n m and the stud m will depress the vertical bar L L, and the outer end of the lever r q s and raise the contact-making jaws s s', so as to establish electrical connections between the plates P' and P''. This movement of S S will not, however, be sufficient to permit the stud e' to engage with the shoulder e of the rocker R, and therefore before A's lever can be released the latch g of his signal instrument must be raised out of the notch b' so as to unlock the bar S S. But, as has been explained, the latch g can only be raised by the magnet M acting on the armature f'—that is, the magnet M must be energized by a current of electricity so as to attract f' and raise the lever G and its latch g.

The signalman at B having then drawn out the knob H and operating bar S S as far as the latch g and slot b' will permit, and having thus established electrical connection between his magnet M and C's signal instrument, B would then ask C by telegraph or ringing an electric bell to unlock his, B's, operating bar. If the line between B and C or section 3 was then clear, C would do this by pressing the plunger P of the signal instrument at his station into the position in which it is shown in fig. 27. This action, as has been explained, and as is shown in the figure, produces electrical contact of the pin n', on the conducting strip N, with the conducting strip Q, thus creating an electrical connection between N and Q. Referring now to fig. 10), which releases his signal lever L, fig. 5. When the lever G, fig. 20, is raised up, it permits the lower end k of the arm g' on the T-shaped lever h i j g' to engage below the end of G and move toward the right. This movement carries the horizontal arm h i' and the vertical rod h h' connected to it downward. The latter, acting on the short arm a'' on the shaft K, lowers the indicator B so as to bring the word "CLEAR" (see fig. 26) in sight behind the slot o, which indicates to B that his operating bar is then free, and that he can draw it out and release his signal lever.

When the bar S of the instrument at station B is moved to its extreme outward limit, as shown in fig. 25, the stud o'', acting on the bell-crank o'' n m, depresses the vertical bar L L, which in time acts on the lever r g s, raises up the circuit-making jaws s s' past the plate P' and breaks its electrical connection with P', by which a circuit was formed between C's battery Z (see fig. 32), and B's magnet M, when n' was brought into contact with Q by the operation of C's plunger.

As the operating bar S in the instrument at station B is now locked in its extreme outward position by the latch d, and can only be unlocked by the action of the magnet M, and, as has been explained, the circuit between C's battery and B's magnet is broken by the movement of the lever r g s, when the bar S at station B was drawn outward to its extreme limit, it is obvious that when B's signal lever has once been unlocked by C to enable B to admit a train to section 3, that C then cannot unlock B's operating bar S S a second time. As soon

Fig. 32.

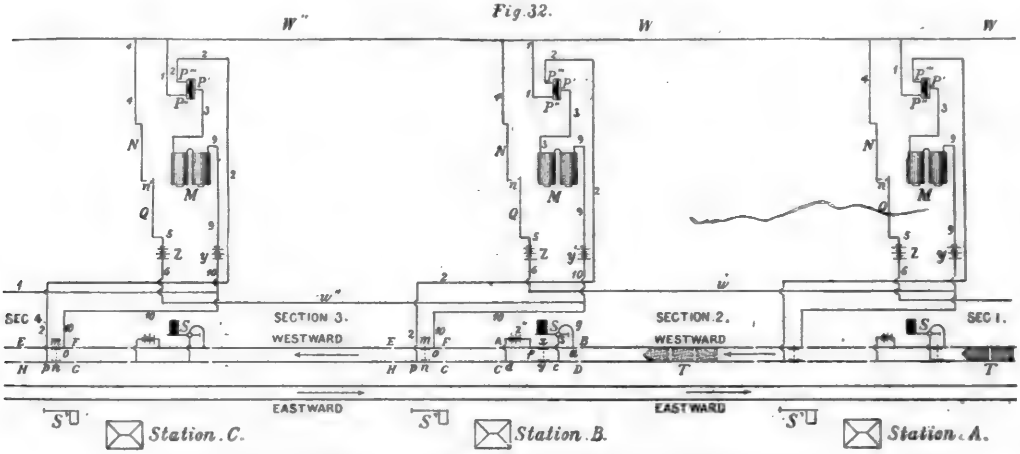


DIAGRAM OF CIRCUITS OF PATENALL'S SYKES' SYSTEM OF BLOCK SIGNALS.

station C, in fig. 32, in which the relation of the principal parts of the signal instruments and their connections is indicated, it will be seen that the strip N is in permanent electrical communication by a wire 4—also shown in fig. 20—with a line wire W'', fig. 32, and the strip Q is connected by a wire 5 with a battery Z. This battery is connected by the wire 6 to the line wire w'' and thence by the wire 10 and 9 to the magnet M at station B. This magnet is connected by the wire 3, 3 to the plate P', which is placed in electrical communication with P'' by the contact making jaws s s', figs. 20 and 23. P'', fig. 32, is permanently connected to the line wire W'' by the wire 1 1.

It will thus be seen that if the signalman at B pulls out his operating bar S S, fig. 20, as far as the slot b' will permit, and has thus established electrical connection between P' and P'', his instrument is then in adjustment to have his operating bar and signal lever released by the signalman at C. Having done this, if he asks C to release the signal at B, and C plunges to B, he—C—will, as described, create an electrical connection at n' at station C, and establish a circuit from the battery Z on the path 5, Q, n' N 4, W'' 1, 1, P'', P', 3, 3, M, 9 10 w'', 6 to Z. The electrical current will thus flow from the battery at station C through the magnet M at station B, and will thus attract the armature f', fig. 20, raise the lever G and latch g, which releases the operating bar S S.

B can now draw out the operating bar S S to the extreme outward limit of its movement. In doing this the pin e' operates the rocker R and raises the rod C' and latch k (shown in as this circuit is broken the magnet M loses its vitality and releases its armature f', fig. 25, and allows the lever G and latch g to fall and engage with the notch b'' when the bar S is drawn out to its full limit. When the movement of this bar is completed s remains in contact with the plate P'—which is connected to the magnet M—and s' is in contact with P''', which is connected by the wire 2, 2, 2 (see fig. 32), with a track circuit, E F G H at station B. This connection is shown direct to simplify the diagram, but in practice a relay is interposed between the magnet M and the track.

The outward movement of the operating bar S S, fig. 20, also brings the cam J in contact with the roller r', attached to the arm h i' of the T lever. The effect of this is to raise up the outer end h of the lever and the rod h h', which operates the shaft K and raises the indicator B so as to display the word "BLOCKED" behind the slot o. When the arm g' is moved to the left, the arm G falls behind the end k into the position shown in fig. 25, and thus holds up the indicator until the armature f' is again attracted by the magnet M. It will thus be seen that as soon as the signalman at B or any other station is permitted to admit a train to the section ahead of him, his signal instrument indicates that that section is "BLOCKED." This indication cannot be changed until the magnet M is energized and attracts the armature f' and raises the arm G, which will permit the arm g' of the T lever to move toward the right, and the arm h i' and rod h h' to fall, which will lower the indicator B.

It has been explained that when B plunged to A to admit a

train from A to section 2, that the drop-plates I and j' fell into the position in which they are shown in fig. 24, and effectually locked B's plunger, and thus prevented him from plunging a second time and admitting another train to section 2 until these drop plates were raised up. It has also been described how an electrical connection was established in B's instrument between the plate P' and P''', when his operating bar S' S was pulled out into the position in which it is shown in fig. 25. The plate P''', as has also been explained, and as is shown at station B, in fig. 32, is connected by a wire 2, 2, 2, 2, at p, with a rail H G of a track circuit E F G H.

It will also be seen from the same figure that the magnet M, at station B, is in electrical communication by a wire 9, 9, with a battery y', which is also connected by a wire 10, 10 to the rail E F of the track circuit. When, therefore, the train which is on section 2 reaches this track circuit, and a pair of wheels gets into the position m n, it will close an electrical circuit and permit electricity to flow from the battery y' through the path y 10 o m n p 2 2 2 2 P''' P' 3 3 M 9 to y'. The effect of this is to energize the magnet M of B's instrument and thus attract its armature f and raise the latch g, and thus unlock B's operating bar S' S. He can therefore push it inward if there is occasion to do so.

From fig. 25 it will be seen that when this bar is drawn outwardly to the full extent of its movement that the vertical bar E E is depressed, and that the nose l'' on the swinging bar E comes below the nose p'' on the drop-plate j'. When the bar S' S is pushed inward the stud o'', acting on the bell-crank o'' n m, raises up the vertical bar L L and E, which latter carries the plates j' and I with it, and thus restores them to the position in which they are shown in fig. 20. When the plate I is raised up it takes with it the indicator B', so that the words "TRAIN PASSED" will be displayed in the slot o', and B's indicator will read "Train passed from A." *

Section 2 now being clear, and the plunger of B's signal instrument being in condition to be operated, he can plunge to A to admit another train to section 2, if requested to do so by A. It must be kept in mind that before B can unlock A's instrument, A must draw out his operating bar as far as the elongated slot b', fig. 25, will permit, which will bring the lug of his instrument c between the abutments a a'. This movement as explained establishes electrical communication (see fig. 32) between the plate P and P' at his station, thus creating a circuit from station B on the path n' N 4 W' 1 P'' P' 3 M 9 y w' 6 Z 5 Q to n'.

It will therefore be seen that there must be a co-operation of the signalman at each end of a section before a "CLEAR" line signal can be given or received. The signalman at the end of a section is powerless to allow a "CLEAR" line signal to be given for the section behind him until the previous train, which has been on that section, has passed over the track circuit at his station. This system, therefore, as it has been expressed, provides an "automatic system which interlocks with the signalmen." This it is thought gives the highest degree of safety attainable.

When a train has reached A, and he has set his instrument to be unlocked by B, and B has plunged to A, B's plunger is then locked by the falling of the drop-plates j' and I. These cannot be raised in any other way than by first drawing the operating bar S' S outward to the full extent of its movement, so that the nose l'' will come below p'', and then by returning this bar to its inmost position. B's operating bar when in its inward position is, however, locked by the engagement of the latch g in the notch b', and can only be unlocked by C, the signalman ahead of him. If C should do this, and B should then pull out his operating bar as far as it will go, so as to be able to raise the drop-plates, it would then be locked by the latch g engaging with the notch b'', and electrical connection between B and C would be broken. It would then be impossible for B to return his bar, and until he did this he could not plunge to A. Under these conditions the only way that his operating bar can be unlocked is by the passage of the train, which was admitted to section 2 when B plunged to A, and its passage over his track circuit.

It will thus be clear that not only is it impossible for B to admit a train to section 2, until the first one admitted has passed out of it and on to the track circuit at B, but it is equally impossible for C to plunge to B until section 3 is clear.

When the operating bar of a signal instrument at any station is drawn out into the position shown in fig. 25, it is then impossible for the signalman to plunge to the station behind him. He is, however, free to move his signal levers and lower his signals to admit a train approaching his station to the section beyond. Having done this, it is now of the utmost importance that a second train should not be allowed to enter this section so long as there is another train on it. It has been explained that if through carelessness or misapprehension of any kind a signalman should forget to return his signal to danger behind a train, that provision has been made to guard against such oversight. This is the electric slot instrument and track circuit, which was described in our second article, with which this system of signals is supplemented. Such a circuit is shown in our diagrammatic plan, fig. 32, and is similar to the one illustrated in our article referred to. This is shown at each end of the stations. Thus at station B, A B D C represents the track circuit. If a train should pass the signal at this station and the signalman should omit to raise his signal behind it as soon as the train reached the track circuit, and a pair of wheels, x y, produced an electrical connection between the two rails, the effect would be to short circuit the current of electricity, and instead of flowing from the battery z'' through the magnet s in the slot instrument in the path z'' d c s g a f to z''. The current would thus be cut off from the magnet in the slot instrument, and the effect would be to raise the signal at this station in the manner which has already been described. In practice a single-track circuit with a relay is often used for both the electric slot and the signal instrument, so that one track circuit will answer for both. We have illustrated our article with two track circuits, because their operation may be followed more easily than is possible if the two are combined in one.

It was also explained that the signal instruments for the west-bound track only are shown in fig. 32 and described above. S', S, S are the signals which refer to the east-bound track. Duplicate signal instruments, exactly similar to those which have been described, are provided to control the signals on the east-bound track. Their connections are, however, arranged so that the same line and track wires answer for both sets of instruments.

The operation of this system of signals may be summed up as follows:

1. No signalman can give a clear line signal without the co-operation of the operator at the next station ahead of him—that is, the man at the station ahead must unlock the signal at the station behind him before it can be lowered to indicate "LINE CLEAR" for the intervening section.

2. A signalman at a station ahead cannot unlock the signal at the station behind him a second time until the train admitted from the station in front of him has passed his station.

3. It follows from these conditions, as stated in our first article, that a train can only be admitted to any block section through the concurrence of the operator at the entering station with the one at the other end, and if a train has been admitted on any section under the system described, such concurrence is not possible a second time until after the train has passed out of the section. Therefore the system complies completely with the law that "two trains cannot at the same time occupy the same space or block section at the same time."

For the special modification of the Sykes system which we have described, the inventor, Mr. Patenall, claims in his patent:

"While my present apparatus embodies some of the generic features of what is commonly known as the Sykes Block Signal System, it differs therefrom in this, that while in the Sykes system the signal operating levers are locked in both the positions of 'line blocked' and 'line clear,' my present apparatus provides for locking the signal operating mechanism in the position of 'line blocked' only, leaving it, when in the position of 'line clear,' free to be manipulated to throw the signal either to 'danger' or 'safety,' as may be desired, while at the same time I provide means for preventing 'plunging' to a station in the rear a second time until the train shall actually have passed out of the block and into the next succeeding block. My invention further contemplates a normally twice-broken plunger circuit requiring an intentional setting of an instrument at any station before it can be successfully plunged to by the next succeeding station; means for shifting the closed plunger circuit to the closed track circuit, and the simultaneous breaking of the plunger circuit; means for regulating the movement of the plunger and indicator in connection therewith, and in various details of structure and arrangements of parts."

These signals are manufactured by the Johnson Signal Company, of Rahway, N. J., and are now in operation in the tunnel of the New York Central & Hudson River Railroad in New York City, and on the southern portion of the Hudson River Division of that line; also on the Shore Line of the New York, New Haven & Hartford and Old Colony system from New Haven to Providence.

* Sometimes this part of the indicator which is seen under these conditions is left blank, so that it then reads "——— FROM A."

TWENTY YEARS' PROGRESS IN TURRET SHIP CONSTRUCTION.

After considerable controversy anent the comparative merits of broadside and turret armaments for sea-going battle-ships, the determination to build mastless turret ships for extended sea service, depending entirely on steam for purposes of locomotion, led up to the design of the *Devastation*. This vessel was completed in 1873, and at the brilliant naval display which took place off Portsmouth in that year she was the cynosure of all eyes, being the most powerful battle-ship of the fleet, and represented the latest ideas of naval designers. Iron was the material used in her construction, and the primary features of the design were a low freeboard hull, 285 ft. long × 62.25 ft. beam, with a displacement of 9,837 tons, carrying two turrets on the middle line of the ship. A belt of armor extended from stem to stern (fig. 1), having a maximum thickness of 12 in. amidships and tapering to 10 in. toward the extremities. On the turrets 14-in. plates were worked, and the breastwork surrounding the turrets as a protection to their bases was plated with armor varying in thickness from 10 in. to 12 in. The total weight of armor carried represented 2 900 tons. She was armed with four 12 in. 35-ton muzzle-loading guns, mounted two in each turret, firing a projectile of 700 lbs. with a muzzle velocity of 1,390 ft. per second. This projectile could pierce 14 in. of unbacked wrought-iron armor at 1,000 yards, the weight of the charge of gunpowder being 140 lbs. The motive machinery was of the direct-acting trunk type, and on the official trial in 1872 a speed of 13.84 knots was attained, the engines indicating 6,637 H.P. Her subsequent behavior at sea fully justified the predictions of her designer, and all doubts as to her stability and sea-going capabilities which had been raised in the minds of the general public by the capsizing of the ill-fated *Captain* were set at rest.

As the spirit of progress moved forward, other types were created, in which hydraulic power replaced steam in the manipulation of turrets and guns, and mechanical appliances performed the work previously accomplished by manual labor. Not only did armor increase in thickness, but the artillery carried developed at a rapid rate both as regards weight and penetrative power. An enormous step in advance was made with the laying down of the *Inflexible* at Portsmouth in 1874, both in offensive and defensive power. In this vessel the complete armor belt was abandoned, and only the citadel, which extended for a length of 110 ft. amidships, afforded protection. The iron armor was disposed in two thicknesses of 12 in. each, with a layer of wood between. The turrets were formed of steel-faced armor 16 in. thick, placed *en echelon* above the citadel, and worked by hydraulic power. By this arrangement all four of her 80-ton weapons could be discharged simultaneously right ahead, or astern, or on either beam. These guns were the heaviest ever mounted on a British battle-ship, and the weight of projectile fired reached 1,700 lbs., with a penetrative capacity of 23 in. of wrought iron, at a distance of 1,000 yards. She was provided with propelling machinery which at the trial developed upward of 8,000 H.P., and maintained a speed of 13.8 knots. The *Inflexible* was completed in 1881, and in fighting trim she has a displacement of 11,880 tons; her length being 320 ft., and breadth 75 ft. Although weapons of smaller caliber and thinner armor were adopted in subsequent vessels, the same elements of design as obtained in the *Inflexible* were embodied in the *Ajax*, *Agamemnon*, *Colossus* and *Edinburgh*. The two first-named were built of iron, and completed in 1883. They carried four 38-ton muzzle loading guns on a displacement of 8,660 tons, and the maximum thickness of armor was 18 in. In the construction of the *Colossus* and *Edinburgh* steel was largely used instead of iron, the displacement was increased to 9,420 tons, and 45-ton breech loading weapons were mounted, capable of piercing 20.6 in. of wrought iron at 1,000 yards. These vessels were laid down in 1879 and completed in 1886. They were provided with propelling machinery of 7,500 H.P., and in each case a speed of over 15 knots was realized. Compared with the steaming capabilities of the *Inflexible* this was a marked increase, and may be partly attributed to the change of proportions adopted; for while the vessels measure 5 ft. longer than the *Inflexible*, their beam is 7 ft. less, thus making a considerable departure in the under-water form.

At a later period in the development of the turret ship opinion seemed to turn in favor of the concentration of the heavy guns in a single turret, and following out this principle, which had been combined in the *Rupert* many years previously, the *Victoria* and *Sans Pareil* were designed. The former was laid down at Newcastle in 1885 and completed in 1890. An exceptionally powerful armament was provided for in the *Victoria*, consisting of two 110 ton guns mounted in a revolving turret, and firing ahead or on either side; one 30 ton gun firing astern; and twelve 5-ton guns, in addition to machine and quick-firing guns. Besides the artillery armament, which exceeds in weight anything previously alluded to, she was equipped with six torpedo launching tubes for the discharge of Whitehead torpedoes—an addition to the offensive power rendered necessary by the rapid advancement of torpedo warfare. The armored belt varied in thickness from 18 in. to 16 in., and extended over a length of 162 ft. amidships. Above this belt the turret rested on a redoubt, the armor employed in the construction of both turret and redoubt being compound, 18 in. thick. The *Victoria* has a displacement of 10,470 tons, measuring 340 ft. in length by 70 ft. in breadth, and her machinery of 14,000 H.P. has propelled her at a speed of 16.75 knots.

A year after the *Victoria* was laid down, the first keel plate of the *Trafalgar* was placed upon the blocks at Portsmouth, and in this vessel, as well as in the *Nile*, a sister ship, the central citadel system, containing two turrets, was again adopted; the *en echelon* arrangement was, however, abandoned, the turrets being placed in the center line of the ship. These vessels were 5 ft. longer than the *Victoria*, with a beam 3 ft. greater, and the normal displacement was 11,940 tons, or just 60 tons in excess of the *Inflexible's* displacement. In H.P., however, the *Trafalgar* had the advantage of 50 per cent. over the *Inflexible*, giving an increase of 20 per cent. in speed. Compound armor was adopted in the *Trafalgar*, and her belt, which varied in thickness from 14 in. to 20 in., extended over a length of 230 ft. Although in this vessel additional protection was provided at the water-line, both with regard to area covered and thickness of metal used, the maximum thickness of armor covering

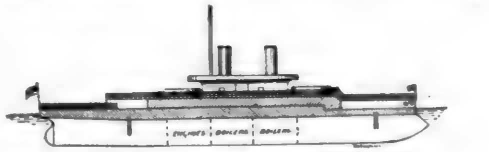


Fig. 1.—Arrangement of Armour, Armament, and Turrets of H.M.S. "Devastation."

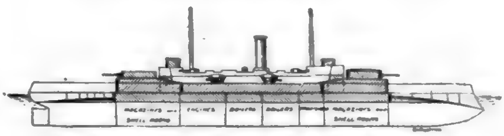


Fig. 2.—Arrangement of Armour, Armament, and Turrets of H.M.S. "Hood."

the citadel and turrets was the same as that utilized for the turret and redoubt of the *Victo ia.* But a great modification was made in the principal armament; four 67-ton guns were mounted, two in each turret, and between the turrets, carried in a box battery, were placed eight 5-in. breech-loading guns. As in the *Victoria*, an equipment of torpedoes and machine guns was included, the latter being mounted on a spar deck. By the adoption of the 67-ton gun the projectile, weighing more than half a ton, has as much force with the same charge of powder, weighing 520 lbs., at a range of 1,000 yards, as the shot from the 80-ton gun of the *Inflexible* has on leaving the muzzle.

The limit of size beyond which it was thought almost imprudent to step in the *Inflexible*, and which was barely exceeded, as measured by displacement in the *Trafalgar*, has been greatly extended in the battle-ship *Hood*, which has recently been completed at Chatham. The *Hood* at once claims the dignity of being the largest as well as the most powerful turreted battle-ship in existence. She undoubtedly represents the acme of perfection in turret-ship design, and embodies all the outstanding points of merit found most serviceable in previous ships. Between the perpendiculars she measures 380 ft., with a beam of 75 ft., and has a sea-going displacement of 14,150 tons. The construction of this leviathan battle-ship was commenced at Chatham in August, 1889, and she was floated out of dock in July, 1891. Triple-expansion engines of 13,000 H.P. have been fitted, capable of propelling the ship at a speed of 17.5 knots. On her recent steam trials the conditions imposed by the Admiralty were easily fulfilled; under natural draft 9,540 H.P. was developed, and the speed attained was 15.75 knots, while with a moderate allowance of forced draft 17 knots was realized, the engines indicating 11,445 H.P. The behavior on service of the monster weapons carried by the *Victoria* has not warranted the appreciation of our naval authorities, and the primary armament of the *Hood* consists of four 67-ton guns, which are supplemented by a powerful

auxiliary armament of ten 6-in. quick-firing guns, disposed in a central battery between the turrets. In virtue of the development of high explosives scrupulous attention was devoted to this auxiliary armament, and in this connection the *Hood* is vastly superior to any turret ship previously constructed. Besides machine guns mounted in the military tops, there are others placed at every possible point of vantage around the hull, and she is further provided with seven tubes for the discharge of Whitehead torpedoes. Her armor is 17 in. thick in the redoubts, 18 in. thick in the turrets, and 18 in. thick in the belt, which affords protection over a length of 250 ft. The arrangement of armor and disposition of the armament is shown in fig. 2. The total weight of armor and backing aggregates 4,550 tons, whereas in the *Devastation* the amount utilized in protection was 2,900 tons. In place of 12 in. of iron armor, then, we now have 18 in. steel-faced armor; the total weight of armament carried by the *Hood* is 1,900 tons, against 515 tons as first mounted in the *Devastation;* the weight of projectile fired has risen to 1,250 lbs., against 714 lbs.; and the weight of charge used 630 lbs., against 140 lbs., while the speed has been increased by fully 25 per cent. These are but a few of the gigantic strides which have been made during the period reviewed; but to describe all the improvements in construction, equipment, and machinery would require much more space than we have at our disposal.—*Industries.*

ties of the same system laid on the line between Brussels and Antwerp, at the end of five years required considerable expense for maintenance, caused by the crushing out of the ballast, while the number of trains was at that time 168,000.

3. *Webb Ties.*—The ties laid in 1880 and 1883 upon the main line of the London & Northwestern Railway were abandoned, because the maintenance was more expense than it was with wooden ties.

4. *Metallic Ties on the Pennsylvania Railroad.*—This company has ceased to continue its tests for the following reasons: They are too light, their price is twice that of wooden ties, they lack elasticity, they are too rigid, and they are easily displaced on curves.

5. *Severac Ties.*—The ties laid between Chantilly and Creil were taken up after having been laid for two years, and carried about 60,000 trains.

6. *Heindl Ties.*—Ties laid between Vienna and Cracovia upon the Northern Emperor Francis Railroad of Austria carried 80,400 trains, and had given excellent results.

The Paris, Lyons & Mediterranean Company still continue tests with steel ties of the Hilf system with Vautherin attachments on the line from Valence to Morians, and upon the line between Toulon and Hyères; but as the number of trains is very low—from 4,000 to 5,000 trains per year over the two lines—it would be only after a lapse of 20 years that it would

FRANKLIN AVENUE FREIGHT DEPOT OF THE "BURLINGTON ROUTE," ST. LOUIS, MO.

COMPARATIVE DURABILITY OF WOODEN AND METALLIC TIES.

In a recent article in the *Revue Generale Chemins de fer*, on metallic ties, the following *résumé* is given regarding the durability of metallic ties on several roads where they have been tested. It was stated in the same article that it was evident that the comparison can only be made of the durability on the ground that they are subjected to the same conditions of wear, and it has been shown that on tracks over which heavy or fast trains are run, a wooden tie which is properly injected ought to carry about 300,000 trains. The question then arises as to how many trains have been run over the principal types of metallic ties, as they have been laid up to the present time, which is as follows:

1. *Vautherin Iron Ties (weigh from 74 lbs. to 97.5 lbs.).*—These ties have been laid for 23 years on the line from Alger to Oran, with the trains running over them at a maximum speed of 31 07 miles per hour, and they were all replaced at the end of 26 years after having carried 70,000 trains.

2. *Post Ties.*—The 137,500 laid on the Netherland State Railway gave satisfactory results at the end of 25 years. The number of trains, however, had not yet exceeded 137,500. The be possible to judge of the value of this system of ties. It is, therefore, the ties which have been laid the longest in Holland and Austria, and upon the State Railways of France, and which up to this time have given perfect satisfaction, that could furnish interesting information; but it is very well known that the number of trains, the tonnage carried, and the number of years during which they have been laid must serve as a point of comparison between the metallic tie and its wooden rival.

FRANKLIN AVENUE FREIGHT STATION IN ST. LOUIS.

We give outside and interior perspective views of a new freight station which has recently been built for the St. Louis, Keokuk & Northwestern Railway, at Franklin Avenue, St. Louis, Mo., being one of the termini of the famous Burlington Route. We also give a cross-section of the roof showing the general method of construction and the plan of arrangement of the track.

The general dimensions are as follows:

Total length, including office building, 884 ft.

Length of shed, 770 ft.

Length of outside platform at north end, 76 ft.

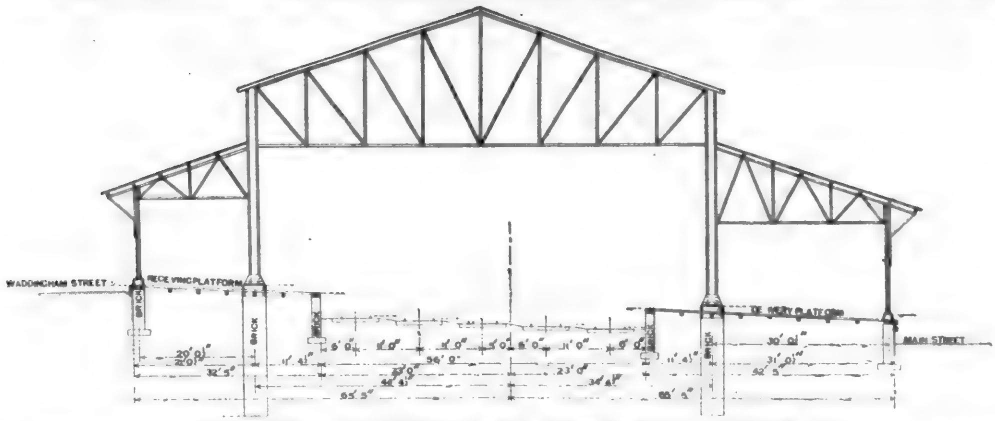
Platforms for delivering freight on east side under roof, 760 ft. × 42½ ft.

Platforms for delivering freight on east side of house outside of roof, 76 ft. × 42 ft.

Total area of delivery platforms, 35,530 sq. ft.

The receiving platforms on the west side under roof are 760 ft. × 32 ft.

the delivery platform slopes downward to the Main Street side of the delivery. This enables cars on the center tracks to be loaded or unloaded from either platform on a downward incline, so that there is no upward haul for the freight handlers. This, of course, greatly facilitates and lightens the work of these men. The general dimensions and spacing of the track and platforms are so clearly given that a recapitulation is unnecessary.



ROOF AND INTERIOR OF FRANKLIN AVENUE FREIGHT DEPOT AT ST. LOUIS, MO.

On the same side outside of roof, 76 ft. × 32½ ft.

Total area of receiving platforms, 27,170 sq. ft.

There are 36 doors, 10 ft. high × 20 ft. wide on each side; there are five tracks under the roof, each 750 ft. in length, giving a total length of 3,750 ft., with a capacity for 100 cars. Outside of the shed, in a small yard north of Carr Street, there is a further track capacity for 50 cars, so that the total capacity of the shed and adjacent tracks is 150 cars.

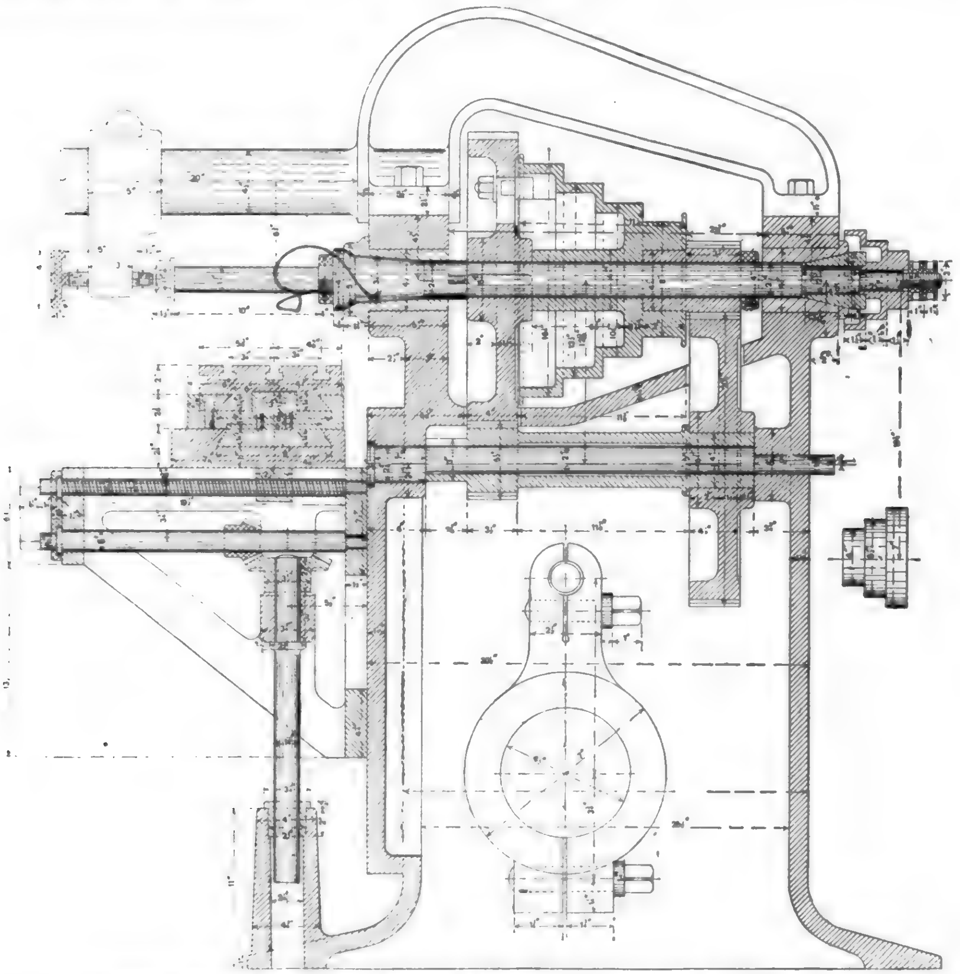
It will be seen by reference to the cross-section that there is a gradual incline downward from Waddington to Maine Street, the former being on the receiving side of the shed. It will also be noticed that the receiving platform has a downward incline toward the first track, and that each successive track is also below the preceding one, until the last one from which

SPECIAL TOOLS OF THE DELAWARE & HUDSON CANAL COMPANY'S RAILROAD.

UNIVERSAL MILLING MACHINE.

Among the tools which have been built by the company for their Green Island shops is a universal milling machine, of which we give a sectional engraving. The general type of the machine is on the style of the Brown & Sharp machine, but it is exceptionally heavy. The engraving is a vertical section through the center of the machine, showing the construction of the driving-gear, with the arrangements for manipulating the table. The spindle is driven by a 2½ in. belt running

on a four-step cone, which may drive the spindle direct or through a back gearing geared in the proportion of 16 to 1. The boxes for the spindle are so arranged that any lost motion due to wear is very readily taken up by the nuts on the back, which draw the step-cone of the feed-belt up against the bushing, thus drawing the spindle back so that it has a bearing on the sharp bevel at the front end. The milling cutter is carried on a separate spindle let into a socket on the main spindle after the manner of a drill chuck, and they are of a size proportioned to the size of the cutter; the one shown in position in the machine being 1¼ in. in diameter.



MILLING MACHINE BUILT AT THE SHOPS OF THE DELAWARE & HUDSON CANAL COMPANY.

The heavy steadying arm projects out and supports the milling spindle through a swinging arm, as shown in the engraving. The table is raised and lowered by hand-power by means of a bevel gear and pinion, as shown, the screw running in a fixed brass nut slipped into a step of the frame in the form of a bushing, as shown. The cross-slides are gibbed over the table and the screws run in brass nuts, as shown. The feed is, of course, a power feed, and is driven by the three-step-cone at the back end of the spindle. The back gearing is thrown out of mesh by an eccentric spindle in the ordinary way, operated from the back of the machine. It will be seen from an examination of the dimensions given that the metal is very thick throughout the whole shell, and great rigidity and solidity are thus obtained for the tool, which is intended to do very heavy work, and it is crowded to the utmost capacity of the cutter. Motion is carried from the feed-gear to the feeding screw on the plate through the universal joints arranged in the forms of gimbals. The machine has now been in operation for several months, and is giving perfect satisfaction.

TRAVELING JACK.

The traveling jack, which is illustrated, presents no very marked features, but is one which has been built by the company for use in their wrecking cars, and has given great satisfaction.

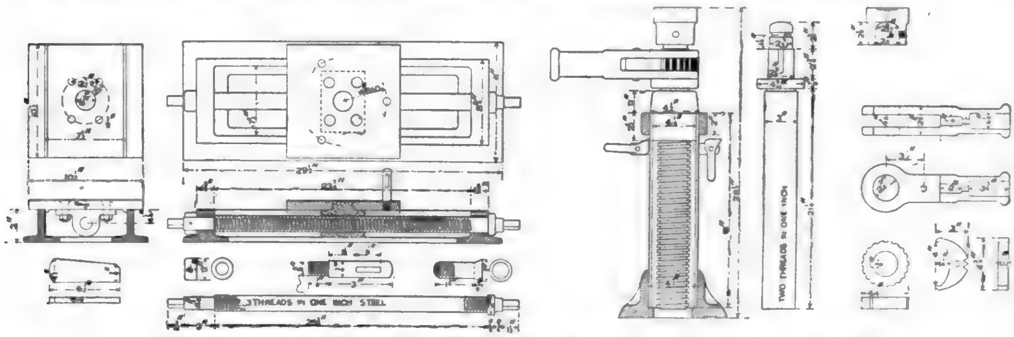
It consists of the ordinary bed-plate with a longitudinal screw having square ends running through it, and having on its upper surface a traveling plate which carries the jack proper. One of the convenient features of the jack are the dowel holes, which are in the plate for the purpose of carrying the jack. The jack itself is shown at the right of the engraving, and is of the ordinary type of ratchet jack. These engravings are presented more for the purpose of giving dimensions and details of a desirable form of traveling jack than that of presenting any very great novelty. There are four of these jacks used in each of the wrecking cars of the road.

EXHAUST TIP REAMER.

There is a very handy exhaust tip reamer in use at the Oneonta shops, by which the exhaust tips can be cleaned with-

out removal of any of the parts, or even opening the front door of the smoke-box. It is well known that exhaust tips very frequently become clogged and closed on account of the dust and sulphur and gases to which they are exposed. This reamer consists merely of a piece of ¾-in. pipe with an auger handle at one end fastened by means of a T, as shown in the engraving. At the other end there is a cross bar with two strips of steel 5¼ in. long, ¾ in. wide, and $\frac{3}{16}$ of an inch thick, bent into the form shown in the detailed engraving at the right. This is of such shape that it will enter the tube, and when revolved and pressed down by means of the handle, which comes out above the top of the stack, will thoroughly clean the tips of any accumulation which may have formed on

one of which sets over the top of the equalizer, and the lower comes beneath the bottom rail of the frame. A ratchet attached to the center of the screw enables the two cross-bars to be drawn together. In doing this the equalizer is drawn toward the frame, and the key over the bar in the center pin is freed so that it can be readily removed. On slacking off the screw the equalizer can be readily lifted, and the keys for the spring hangers at the end removed and the springs readily taken out. The screw that is used is 1¼ in. in diameter, and the nut is 1½ in. long. The hooks are made of iron ¾ in. by 1¾ in., and the ratchet which is rigidly attached to the center of the screw is provided with a dog, which will work it in either direction, so as to tighten or slacken off.

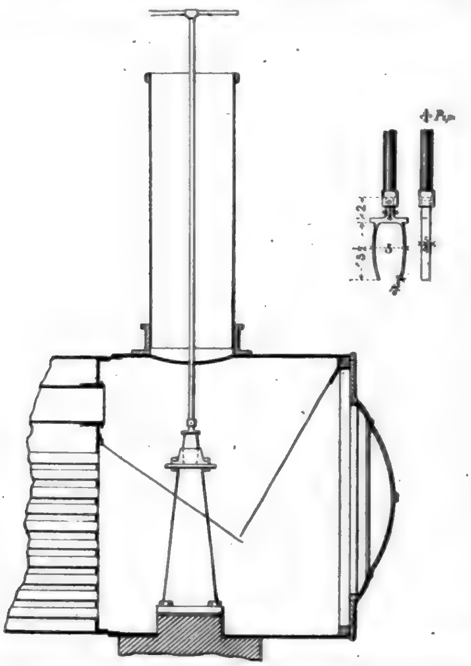


TRAVELING JACK IN USE ON THE DELAWARE & HUDSON CANAL COMPANY'S RAILROAD.

their edges. For its operation it is merely necessary to put it down through the stack and place something on the boiler to raise the man high enough to conveniently work over the top of the stack.

HOOK JACK.

Another convenient little tool is that of a hook jack used for the purpose of removing driver springs. This jack con-

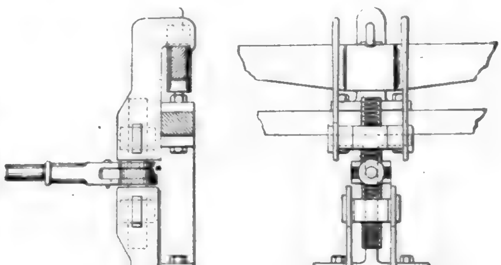


EXHAUST TIP REAMER, DELAWARE & HUDSON CANAL CO.

sists of a right and left-hand screw, working in rigid nuts in cross-bars that are in turn fastened to a set of hooks, the upper

THE USE OF CAST STEEL IN THE MANUFACTURE OF DIFFERENT PARTS OF LOCOMOTIVES.

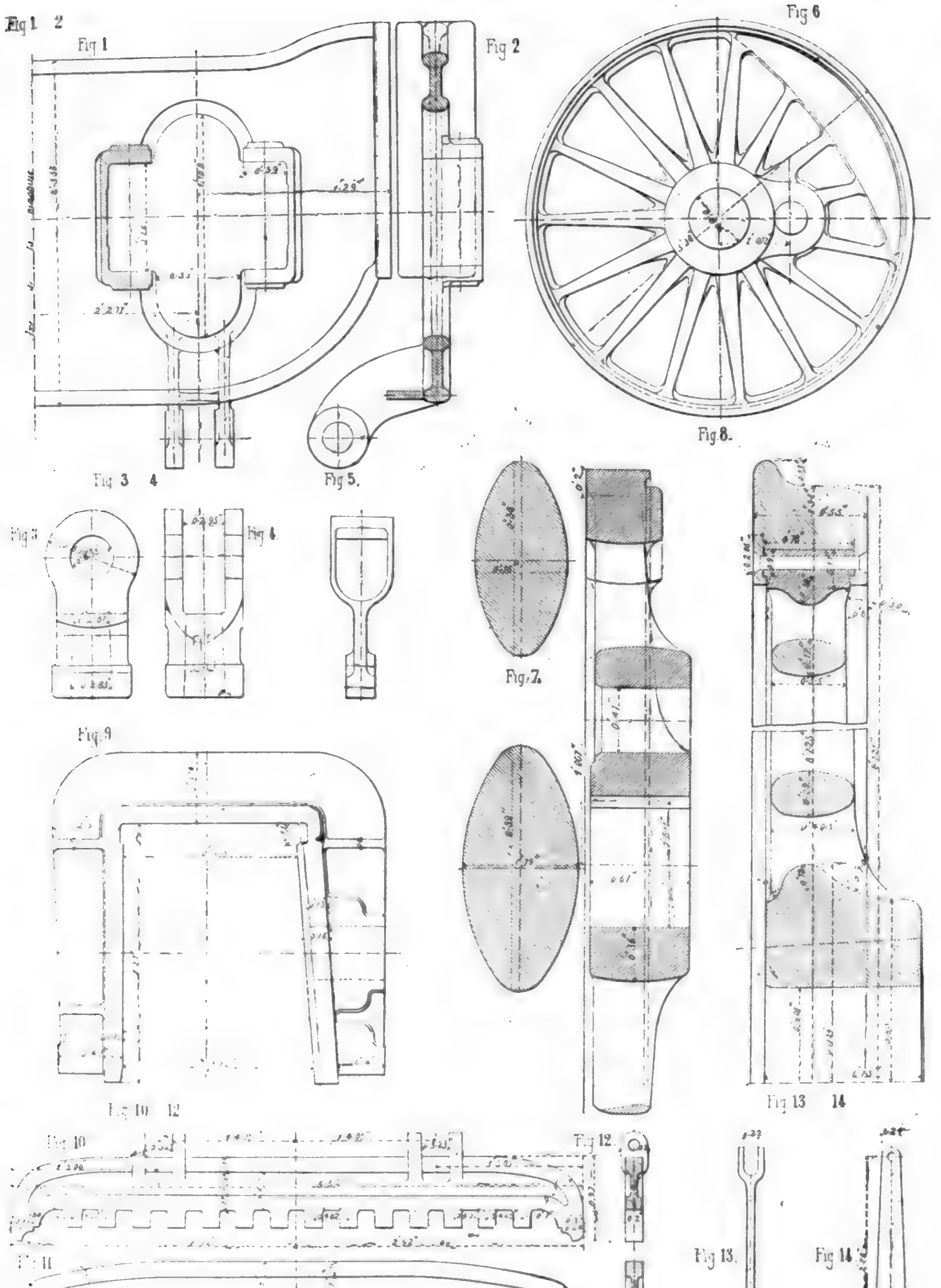
If it were possible to obtain a metal which is cast and run into moulds which possessed the desired qualities of tensile strength and ductility, there is no reason why it should not be used for the manufacture of the different portions of the mechanism of steam-engines instead of wrought iron and forged steel, which has thus far been solely used for these purposes. Cast steel, in spite of the immense progress which has been made in its manufacture, has not yet touched that point, but it is nevertheless possible to use it advantageously, if not for the manufacture of the principal parts, at least for those of the secondary fixed pieces or of certain moving parts, such as cross-heads and pistons, whose dimensions are far in excess of what the actual strength of the material would require.



HOOK JACK, DELAWARE & HUDSON CANAL CO.

Furthermore, cast steel, in having a tensile strength of at least three times that of cast iron, can be very advantageously used instead of the latter, when strength of construction is desired and when the question of weight enters into the consideration.

In locomotive work cast steel has been very extensively used for the past few years by English railway companies. The following is a list of the principal parts of the locomotive which have been made of cast steel by our English cousins, and which were formerly made either of cast iron, wrought iron, steel forgings or stamped work: Guide brackets, various stays, horn plates or pedestal guides as we call them, dome



PARTS MADE OF CAST STEEL USED ON ENGLISH LOCOMOTIVES.

covers and even domes complete, mud rings and fire-door rings, crown-bars, tanks, valve cases, piston-head, slides for the Joy valve-motion, brake details, suspension rods, hinges for smoke-box doors, reversing wheels, various levers and handles, finally, and above all, truck and driving-wheels and in all about 40 different parts.

One reputable house has even made axles of cast steel. One of them was put upon an engine of the North British Railway in 1881, and up to April, 1892, had run 316,900 miles without showing any sign of defects. This is only cited as an isolated case, for it would not be right to consider it as showing even a tendency in that direction, for no engineer would dare to recommend cast steel for the manufacture of such important parts. Furthermore, this metal often has a surface which was far from being smooth enough, and its coefficient of friction is quite high, which alone would seem to remove it from the possibility of being used for the manufacture of journals or other frictional surfaces. In order that the parts of the engines may be cast of steel, with every assurance of solidity and without having any interior blow-holes of large size, special care must be taken for this purpose to have the patterns of as simple a form as possible, and that the difference of thicknesses between the several parts should be as slight as possible and be connected by fillets of large radius. As for the chemical composition of the metal, its resistance and its elongation, considerable variation must be allowed according to the purpose for which it is to be used. For instance, it is evident that the same quality of metal should not be used for the manufacture of gear-wheels as for that of locomotive wheels which are provided with tires.

The acid process usually gives the best results in the manufacture of cast steel for mechanical purposes. The basic process allows too much oxidation when melted.

For beauty and homogeneity of surface acid cast steel can enter very favorably into competition with ordinary cast iron. This is due to a great extent to the high temperature which must be obtained before the metal is brought to a sufficient state of fluidity, and this very fact adds to the difficulty of obtaining a foundry sand sufficiently refractory to support such high temperatures while remaining porous enough, at the same time, to allow the escape of the gases; and, finally, for the greater contraction of the metal without taking into consideration the particular circumstances due to its constitution, which result in the liberation of the gases generated at the instant of solidification, which frequently cause very serious blow-holes to occur unless the pieces are of suitable shape.

The cast steel which is actually adopted in England by the railway companies for different purposes can be divided into four different classes, to wit:

1. A very soft steel with a tensile strength of from 62,500 lbs. to 68,000 lbs. per square inch, and an elongation of from 15 per cent. to 25 per cent. measured along the test piece 10 in. in length. This metal is especially used for those parts which require, above all things, that the coefficient of safety should be very high, such as the centers of wheels, guide brackets, piston-heads, bogie frames, journal boxes, horn plates or pedestals, and, in a word, all parts which are submitted to shocks and offer special facilities for casting and moulding. This metal ought to bend through an angle of 90° cold without showing any crack or flaw.

2. The semi-hard metal with a tensile strength of from 72,500 lbs. to 75,000 lbs. per square in., and an elongation of from 8 per cent. to 15 per cent. This is specially used for the manufacture of gearing, dome caps and other parts intended for frictional service and riveting.

3. A slightly hard steel with a tensile strength of from 83,800 lbs. to 88,000 lbs. per square in., with an elongation of from 3 per cent. to 8 per cent. This metal is especially used for the manufacture of gears, hydraulic pumps and parts which are subjected to continual frictional action.

4. Finally, a hard steel with a tensile strength of 106,600 lbs. per square in., and an elongation of from 1 per cent. to 3 per cent. It is used in certain special cases where hardness is the first requisite. Annealing is an indispensable adjunct in order to obtain a casting free from brittleness and the internal strains due to contraction. This process allows of the transformation of the granular structure of the metal, which has passed into an amorphous state from that of a crystalline, and an absolute suppression of the internal strains which were developed by contraction. Thus it is necessary to avoid, as far as possible, allowing the castings to cool completely before annealing, lest incipient fractures may occur which would be very injurious, and which annealing could not entirely remedy. It is, therefore, necessary to take the casting to the reheating furnaces before it has had time to become entirely cold. But as this is a very delicate operation, and as it is very hazardous to assume the responsibility of doing the work on castings which have not yet been made, the railway companies are usually content to specify that the casting shall be annealed without any further conditions.

Up to the present time the companies have specified a certain tensile strength and elongation, allowing the chemical composition to be determined by the manufacturers. It is not always the best theoretical composition which gives the best practical results. The manipulation holds a place of equal importance with the chemical composition, at least within certain limits. The Lancashire & Yorkshire Railway have made a very extensive use of cast steel, and their best results have been obtained with a metal containing at least 0.28 per cent. of carbon and about five times as much silicon. The poorest results have invariably been obtained with steel containing at the same time too much carbon and silicon.

Our illustrations show a few of the parts which are made of cast steel in England for locomotive work. Figs. 1 and 2 show a guide yoke which is at the same time a brace for the frames. This plate, which is cut out for the admission of the connecting-rod, has two bosses for carrying guides and the lifting-shaft and rests upon the frames upon each side with a large foot. It will be noticed that sharp angles are done away with as much as possible, and that the different portions are connected by fillets of a large radius. Cast steel has almost entirely supplanted cast iron, which was formerly almost universally used for the manufacture of these parts, and it has permitted a reduction of weight; it is very true that this piece could be made still lighter of sheet metal, but at a greater expense.

Figs. 3 and 4 show the head of a piston-rod which is very simple and made so as to connect with a cross-head having double lateral slides.

Fig. 9 is a horn plate or pedestal for driving-axles. It will be remarked that the two guides of each box are cast on, which greatly facilitates their attachment and adjustment.

In fig. 5 we find a hanger for the tender; it is of such shape that it would be a very difficult and complicated piece to forge, but it is readily cast.

Figs. 13 and 14 show a brake-lever with its journal, regarding which the same comment may be made.

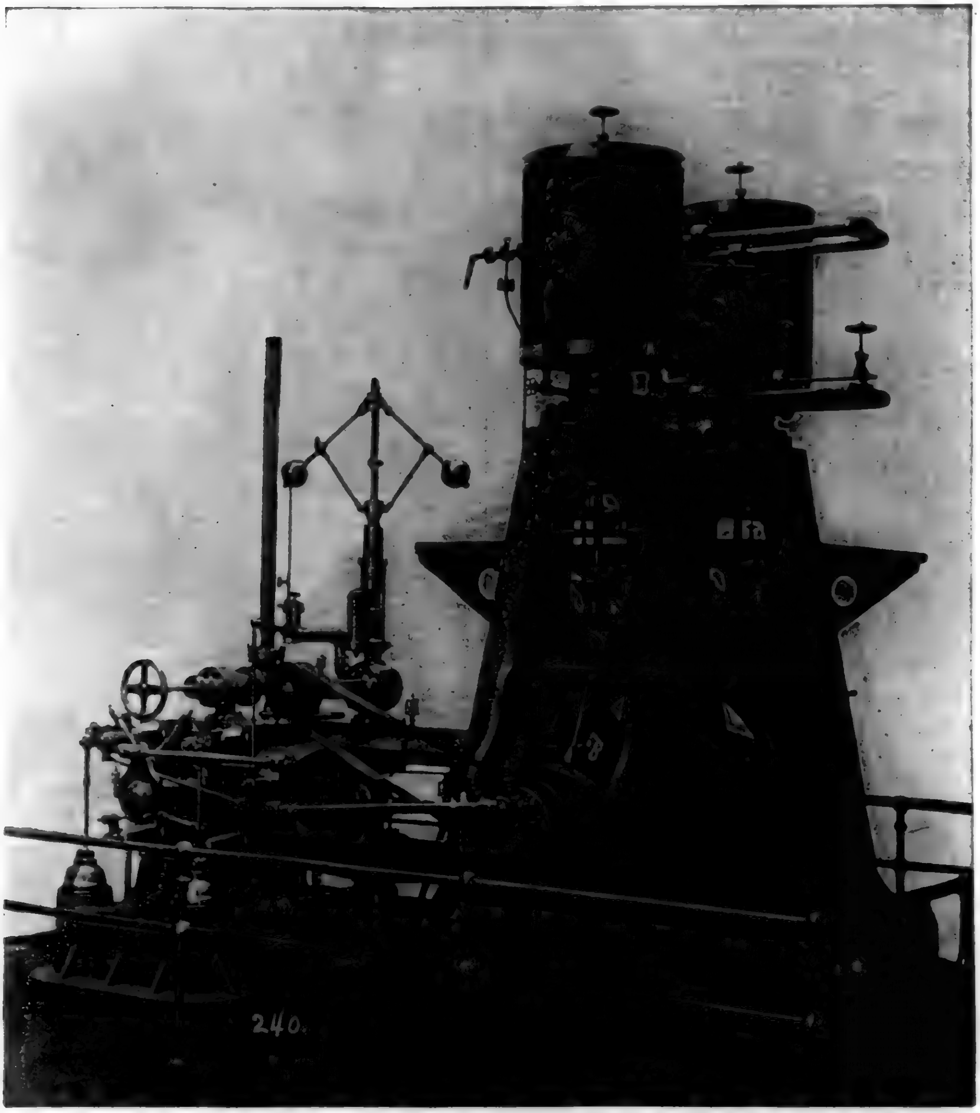
We now come to the principal application which has been made of cast steel to locomotives—that is, the wheels. The English, for special reasons which we do not care to discuss here, have never, as is well known, made wheels by stamping; they have remained faithful to the old welding process and the use of a tire shrunk on. Thus the continually increasing difficulty of obtaining good forgings and the constant rise in the price of manual labor have led them to look with favor upon the use of cast steel for the manufacture of these pieces. At the present time the Midland, North British, the Great Northern, the Manchester & Sheffield, the Lancashire & Yorkshire, Northeastern and all the great companies have adopted cast steel in a general way for the manufacture of their locomotive wheels. This metal has been used for the manufacture of he 8 ft. wheels on the Great Northern express engines and the 7 ft. 9 in. wheels of the Midland.

Figs. 6 and 7 show one of these wheels. To provide for the effect of contraction, the thickness of the rim has been very carefully proportioned to that of the arms, which are of an elliptical section, like the truck wheels usually used in France, and which are of an odd number. Some difficulties are occasionally experienced in casting wheels which have a very large counterbalance, since both in the mould and in cooling slowly they tend to assume a permanent deformation. In order to diminish this effect the counterweight is made hollow, so as to carry the strain over as great a length as possible.

Figs. 10, 11 and 12 are two forms of crown-bars which are now used by many companies, but which were originally introduced by Mr. Worsdell on the Great Eastern Railway about 1883. They have this advantage, in that they can be given that form which seems most desirable without any difficulty at a very low price, and that the different bosses or attachments which they need for the nuts and stays can be readily cast on the pieces.

In the matter of wheels and crown-bars there is this point that must be borne in mind. Cast steel is no longer in its period of trial and probation; for several years it has entered largely into current practice and is gradually supplanting wrought iron for many purposes, and that, too, in a very satisfactory manner.

Wheels are furthermore submitted to tests which are somewhat severe. One wheel out of each lot of 50 is tested under a drop, and test pieces for tensile tests are cut from it. Sometimes the drop test is applied to the whole body of the wheel under conditions incapable of sustaining any deformation if they are sound and well made. For this purpose they let the wheel fall vertically from a height of 2 ft. upon a rail laid



FRICK'S REFRIGERATING MACHINE.

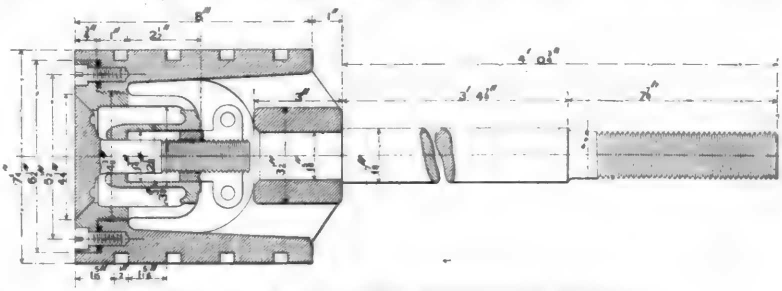
upon a foundation weighing at least 2 tons. The wheel is given a quarter turn and the same test repeated. The wheel is rejected if it shows any sign of deformation or cracks. The wheel is then subjected to successive blows from a hammer weighing 8.8 lbs. swung by hand and striking 20 blows on the rim in a space of 7.9 in.—*Portefeuille Économique des Machines.*

FRICK'S REFRIGERATING MACHINE.

We give a full-page perspective view and two engravings of the details of a refrigerating machine made by the Frick Company, of Waynesboro, Pa. The general appearance of the machine is very clearly shown by the perspective engraving. The machine consists of two single-acting vertical ammonia compression pumps 7½ in. bore and having a stroke of 14 in. They are driven by a horizontal engine having a Corliss valve gear and a cylinder 11 in. in diameter with a piston stroke of 14 in. The special features of the machine are its compactness, the accessibility of its parts, the use of cushions and the noiseless safety discharge gear. Attention is called to the fact that this machine may be used on shipboard or where the ceiling is very low, provision having been made for removing the ammonia from the lower head, or, in other words, from below instead of from the top of the ammonia cylinder as usual. The capacity is twelve tons of ice-melting per day.

Referring to the details, the engraving shows the construction of the ammonia piston. It will be seen that it consists of the piston-head proper, in which are cut the grooves for the packing ring, the cage screwed into the same and the valve. By this arrangement the working parts can be very easily removed for repairs, and the fitting can be much more easily accomplished than were the piston and cage made in one solid piece. The rings are made thin on one side to facilitate springing into place.

The second engraving of details that we present shows the discharge valve of the pump. It will be noted that the valve is the full size of the bore of the pump, and that it is provided with a cushion that makes the operation of the valve noiseless, and, at the same time, the valve and cushion may be lifted together, thus acting as a safety valve to prevent breakage in case any loose piece comes between the piston and the valve. The safety arrangement that is carried by the larger spring practically acts the same as a dashpot and yields slightly at each stroke, preventing the valve from hammering and assisting in bringing it back gently to its seat.



AMMONIA PISTON FOR FRICK'S REFRIGERATING MACHINE.

CUSHION-HEAD FOR AMMONIA COMPRESSOR, FRICK'S REFRIGERATING MACHINE.

Unloading Petroleum at Madras.—Petroleum is unloaded at Madras by being pumped into a 10-in. pipe leading aft in the vessel to a 12-in. flexible rubber pipe, which hangs over the stem and connects with a cast-iron conduit of the same size supported on a raft. From this raft another rubber pipe leads the oil into a cast iron main laid along the inside of the harbor wall to mainland and thence into storage reservoirs.

STANDARD FREIGHT ENGINES OF THE BELGIUM STATE RAILWAYS.

By G. Braet.

The types of freight engines adopted by the management of the Belgium State railways are as follows :

1. Engines with six wheels coupled, 4 ft. 9.3 in. in diameter, type 28.
2. Engines with six wheels coupled, 3 ft. 11.2 in. in diameter, type 29.
3. Engines with six wheels, 3 ft. 11.2 in. in diameter, type 25.
4. Tank engines, type 20.
5. Switching engines, type 51.

Six-wheel Coupled Engines, Types 28 *and* 29.—These locomotives are identically the same as the six coupled passenger engines with 5 ft. 6.9 in. drivers, which are used for heavy grades. The only difference lies in the diameter of their wheels. They are spoked wheels made of hammered iron without any counterweight. They have no wheel brake, but they are provided instead thereof with a Le Chatellier water brake. The first type—that is, type 28—is used on level lines, and the second for hauling trains over heavy grades ; they haul 230 tons up a continuous grade of 16 per cent. at a speed of 10.6 miles per hour.

The management are about to substitute in the operation of lines with average gradients engines of far greater power which

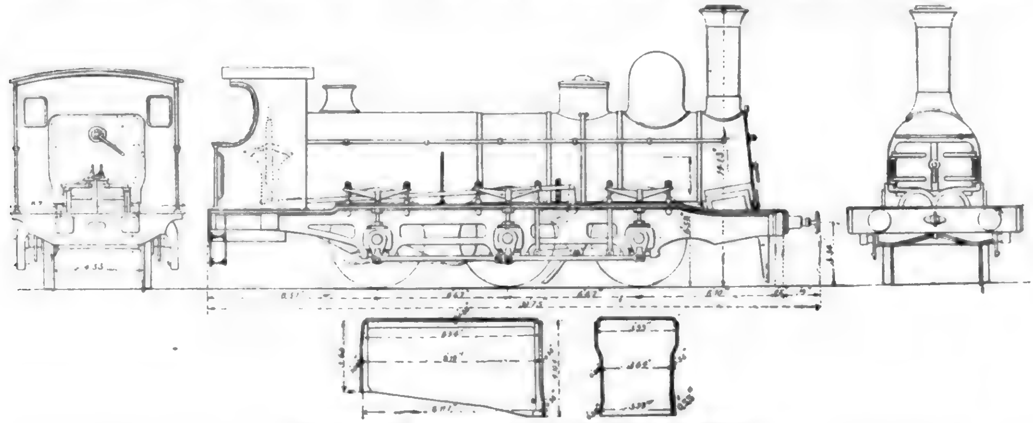
can easily haul the same load of 230 tons at a speed of 30 miles per hour.

3. *Engines with Six Wheels Coupled, 3 ft. 11 in. in Diameter, Type* 25.—The essential characteristics of these engines are great cylinder capacity (19.7 in. × 23.6 in.), large grate area and heating surface, large volume in the smoke-box and great adhesive weight. The arrangement of engines of six wheels coupled has been followed in the construction of this engine There are the inside cylinders, the central frame and the frames outside of the wheels. The steam distribution is on the Walschaert system, and there is a steam reversing gear very similar to that of the express passenger engine used on heavy grades. It is supplemented by a hand lever and a notched quadrant. The valve-rods and piston-rods are guided by their stuffing-boxes and by upper guides, thus varying from the common method of guiding, which consists of the use of double lateral guides. The springs are of the reversed type, and their length is about 4 ft. 11 in., being composed of 23 plates of steel 3.9 in. × .39 in. Between the springs of the driving-wheels and the front coupled wheels an equalizing lever is placed, and there is also one between the two springs of the back axle, so that the engine is made to rest upon three points. This method of hanging gives excellent results. The inside spring is formed of six leaves of steel 3.9 in. × 3 in. and 2 ft. 6.7 in. in length. The length of the fire box is 8 ft. 10.7 in., with a breadth of 5 ft. 9.6 in. It stands above the wheels. The shape is practically trapezoidal; it is made entirely of red copper; the thicknesses of the sheet are the same as has been indicated in the description of engine No. 2, published in our May issue. The shell and the outside envelope of the fire-box are made of iron .55 in. in thickness; the tubes are of brass. Steam is taken from the dome, and the throttle valve is located in the smoke-box. There is a washout plug in the bottom of the shell and the delivery pipes from the injector discharge at the same point.

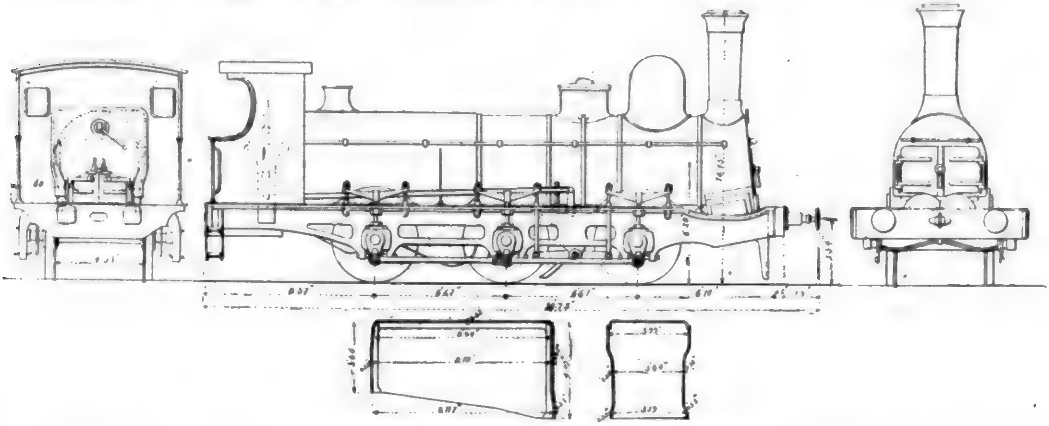
Wilson safety valves are placed over the fire-box, and just ahead of the dome there is a sand box with pipes leading down so as to deliver the sand in front of the main driving-wheels. The fire box door is composed of a single folding sheet round and swelled out. The handles for closing the door are in the center and the hinges are at the side. The stack is rectangular. The engine is provided with the Le Chattellier water brake, and the lubricators oil the valves and cylinders separately.

This engine is provided with a tender having three axles, with a capacity of 3,698.5 galls. The tender springs are of the reverse form 4 ft. 11 in. in length, and those of the forward axles are connected together by an equalizing lever. The tender is not subjected to the tractive resistance of the train, and the locomotive is attached directly to the latter by means of a long bar which passes beneath the tender, and to which the front car is coupled. The tender, on the other hand, is fastened directly to the engine by a short bar connecting its front end sill to the tail bar of the engine.

In the course of some experiments made with the boiler of an engine of type 25, 50 galls. of water have been evaporated per minute.



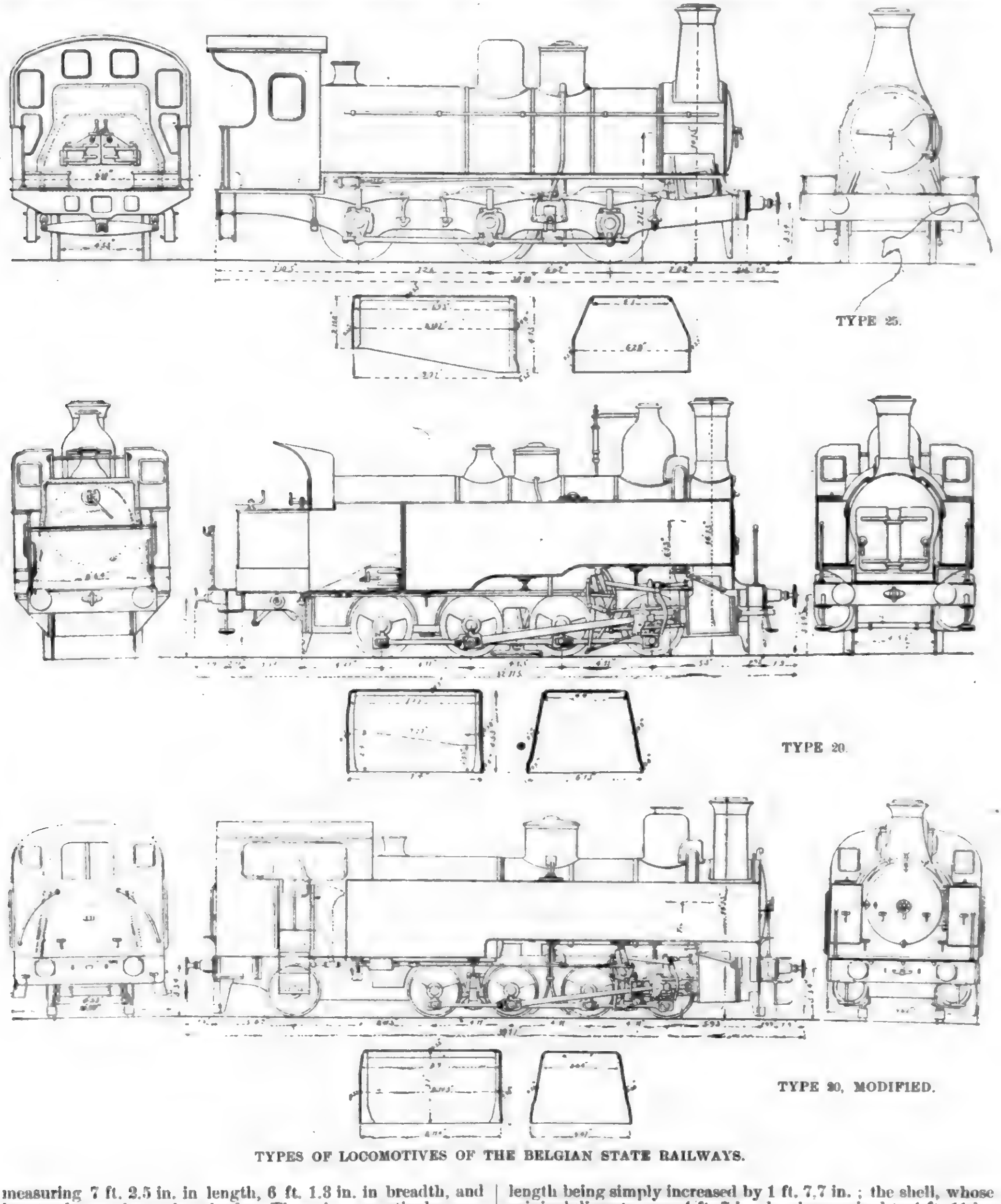
LOCOMOTIVE OF THE BELGIAN STATE RAILWAY, TYPE 28.



LOCOMOTIVE OF THE BELGIAN STATE RAILWAY, TYPE 29.

4. *Locomotive, Type* 20.—This engine was built for hauling trains up the Liege grade of 3 per cent. It is an engine with a tender having 8 wheels coupled, the latter being 3 ft. 5 in. in diameter with outside slightly inclined cylinders. The two frames inside of the wheels are braced across at the front, the back, at the smoke-box and fire-box, by cross braces and by an intermediate cross brace between the front axle and the one

immediately behind it. The main driving axle is third. Counterweights are used in the driving and coupled wheels; they are of plate iron and perfectly smooth. The reversing lever is operated by hand, and is of the ordinary standard type used on the State railways. The steam distribution is of the Belpaire type, a valve on one side being controlled by the piston on the other side. The fire-box is of trapezoidal section, the grate line running from Spa to the frontier. The capacity of the water tanks has been raised from 1,743.6 galls. to 2,906 galls., and the coal space from 4,189 lbs. to 9,922 lbs. The dimensions of the principal details have also been increased, but the system of mechanism has been left intact with the exception of the cylinder, whose diameter has been raised from 18.9 in. to 19.7 in. The form of the fire-box has been preserved, the



TYPES OF LOCOMOTIVES OF THE BELGIAN STATE RAILWAYS.

measuring 7 ft. 2.5 in. in length, 6 ft. 1.3 in. in breadth, and it extends out above the wheels. There is no particular novelty presented by the boiler itself or its attachment. The machine is provided with a track brake between the second and third wheels, and it is also further provided with a Le Chatelier water brake.

This engine has also been subjected to some changes so as to make it suitable for the services on the heavy grades on the line length being simply increased by 1 ft. 7.7 in.; the shell, whose original diameter was 4 ft. 7 in., has been raised to 4 ft. 11 in. in the modified engines. This is the largest diameter which they have ever given the shell of a locomotive boiler up to the present time. The excessive weight resulting from these modifications is carried by a fifth pair of wheels located at the back of the machine. The axle of these wheels is provided with radial boxes to permit the passage of the engine over

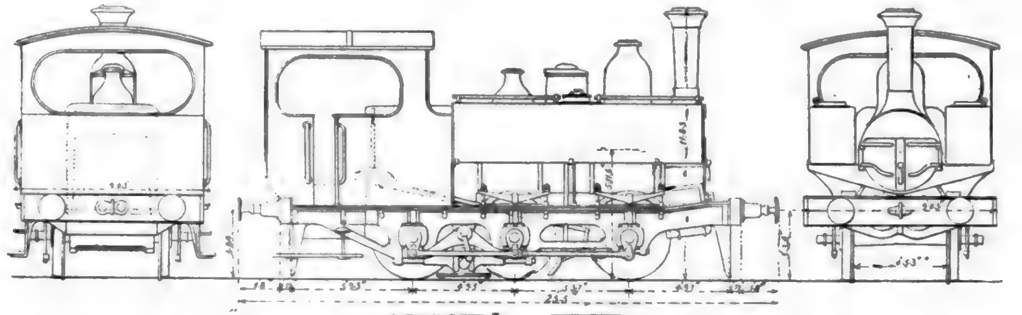
curves of 150 ft. radius. The engine is further provided with a steam brake, which may be made to operate at will upon two or the whole four pairs of wheels; a Dewrance valve controls the manipulation of this brake and allows its action to be modified at will.

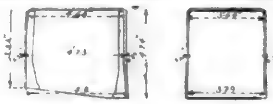
The engine may be reversed by hand by means of an ordinary reverse lever, or by a screw, or by means of a motor located beneath the running board, as shown on the side elevation.

Two equalizing levers are used upon each side to connect the springs of the three front pairs of wheel, the third equalizer being used to make connections between the springs of the rear pair of driving-wheels and that of the truck wheels at the back. A large cab affords complete shelter to the engineer and firemen. The stack is of rectangular section, and the smoke-box, whose length is somewhat prolonged, has a large capacity for the better regulation of the draft; the exhaust steam discharged in this large space, and mingling very intimately with the products of combustion, quickly and easily communicates its momentum to them, thus readily driving them out of the stack. The shell is .6 in. in thickness. Wilson safety valves are used with a diameter of 4 in.

The frames have a thickness of 1.2 in., and are spaced 4 ft. 4 in. apart between the driving-wheel and 3 ft. 10.7 in. apart between the rear truck wheel. The springs of the driving-wheels are formed of steel plates 3 ft. 3.4 in. × 3.9 in. × 3 in.; that of the trailing axle is composed of 16 offset leaves 3 ft. 11 in. × 3.1 in. × .5 in. The railway has only one example of this type of machine.

5. *Switching Engine, Type* 51.—This is a tank engine with three frames and three axles. The interest which attaches itself to this engine lies entirely in its dimensions and proportions, which are given in *résumé* in the annexed table. The construction offers no especial peculiarity, and it is similar to that of ordinary engines, types 2, 28 and 29. It is provided with a track brake, which is operated by hand in some locomotives, the manipulation of the brake being controlled by a steam cylinder in which it is possible to modify and vary the action. The combination of the details of this brake offers this peculiarity, that it frees the suspension springs of the engine from the reactions of the brake upon the rail, and while it is in operation they do not lose their load or their play.





LOCOMOTIVE OF THE BELGIAN STATE RAILWAY, TYPE 51.

Freight Locomotives.	Type 28.	Type 29.	Type 25.	Type 20.	Type 20 (Modified).	Type 51.
Diameter of cylinders	17.7"	17.7"	19.7"	18.9"	19.7"	15"
Stroke of pistons	23.6"	23.6"	23.6"	21.7"	21.7"	18.1"
Center to center of cylinders	19.7"	19.7"	22.4"	78.8"	78.8"	19.7"
Length of connecting-rod	7' 3"	7' 3"	7' 3"	9' 3"	9' 3"	4' 5.9"
Center to center of valves	3' 7.3"	3' 7.3"	3' 6.5"	6' 6.9"	6' 6.9"	3' 7"
Length of eccentric rods	4' 3.7"	4' 3 7"	4' 9.8"	6' 6 9"	6' 6 9"	2' 1.5"
Type of valve motion	Stephenson.	Stephenson.	Walschaert.	Belpaire.	Belpaire.	Walschaert.
Diameter of driving-wheels	4' 9"	4' 3.2"	4' 3.2"	3' 5.3"	3' 5.3"	3' 11"
Total wheel-base	13' 1.5"	13' 1.5"	13' 9.4"	14' 9.3"	23' 8.6"	3' 10.2"
Center to center of wheels	6' 6 7" 6' 6.7"	6' 6.7" 6' 6.7"	6' 6.7" 6' 6.7"	4' 11" 4' 11" 4' 11"	4' 11" 4' 11" 4' 11"	5' 4.6"
Length of grate	8' 7.3"	8' 7.3"	8' 8.5"	6' 10 7"	8' 11.4" 8' 11"	4' 9 5" 4' 3"
Width of grate	3' 5.5"	3' 5.5"	6' 2.8"	5' 10.8"	6' 1.2"	3' 6"
Grate area	24.83 sq. ft.	24.83 sq. ft.	55.42 sq. ft.	40.7 sq. ft.	54.5 sq. ft.	14.9 sq. ft.
Length of fire-box outside	9' 6.6"	9' 6.6"	9' 7"	7' 10.5"	9' 1.7"	5' 3"
Width of fire-box at the bottom	4' 2.8"	4' 2.8"	6' 8.6"	6' 8.5"	6' 8 5"	4' 2.7"
Length of shell of boiler	11' 2 4"	11' 2.4"	10' 9"	13' 1.8"	12' 4.6"	8' 8.3"
Diameter of boiler	51 2"	51.2"	55.1"	55.1"	59.05"	44.9"
Thickness of sheets	.52"	.52"	.55"	.47"	.78"	.63"
Height of center of boiler above rail	6' 5 9"	6' 2 8"	8' 11"	7' 4.4"	7' 6 6"	6' 1.8'
Maximum pressure in lbs. per sq. in	120	[illegible]	150	135	150	120
Length of tubes	11' 6.2"	11' 6.2"	11' 6.2"	13' 1.5"	13' 1.9"	9' 3"
Number of tubes	226	226	251	251	242	165
Outside diameter of tubes	1.8"	1.8"	1.8"	1.8"	1.8"	1.8"
Diameter of stack at bottom	18 3"	18.3"	51.2" × 30 2"	19.7"	51.2" × 26.1"	13.4"
" " " at top	20.9"	20.9"	22.8" × 21.6"	21.6"	22" × 21.6"	16.4"
Height of top of stack above rail	14' 1.3"	14' 1.3"	14' 1.3"	14' 1.3"	14' 1.3"	11' 7.4"
Position of frames	Outside	Outside	Outside.	Inside.	Inside.	Outside.
Length of locomotives without buffers	28' 10.5"	28' 10.5"	29' 8"	29' 3 96"	35' 7.1"	21' 8"
Heating surface fire-box	109.4 sq. ft.	109.4 sq. ft.	121.95 sq. ft.	121.5 sq ft.	141 sq. ft.	57.04 sq. ft.
" " tubes, outside	1060 "	1060 "	1241 "	1334 "	1453 "	604 2 "
" " total	1169.4 "	1169.4 "	1362.95 "	1455.5 "	1594.5 "	661.24 "
Total weight of engine, empty	32.1 tons.	31.8 tons.	39.8 tons.	39.7 tons.	57 8 tons.	24.3 tons
Weight on front drivers in working order	11.2 "	11.1 "	14.6 "	13.1 "	14.72 " 14.72 "	10.02 "
" " intermediate drivers in working order	12.8 "	12.3 "	14.8 "	13.0 " 13.6 "	15.13 " 15.03 "	10.86 "
" " back " " " "	11.1 "	11.4 "	13.8 "	13.7 "	15.12 "	9.74 "
Total weight of engine in working order	35.1 "	34.8 "	43.2 "	52.4 "	75. " *	30.62 "
Available adhesive weight	35.1 "	34.8 "	43.2 "	52.4 "	60. "	30.62 "
Number of coupled axles	49	[illegible]	50	....	....	52
Capacity of boiler	1,474 galls.	1,474 galls.	1,690.9 galls.	1,820.9 galls.	1,425.4 galls.	801.6 galls.
" " water tanks	....	....	....	1,743.6 "	2,906 "	1,056.7 "
" " coal space	....	....	....	4,189 lbs.	9,922 lbs.	29,767 lbs.
Weight of locomotive, empty	70,780 lbs.	70,114 lbs.	87,754 lbs.	87,583 "	12,736 "	53,582 "

* These figures may be exceeded if we utilize the whole capacity of water tanks and the coal space.

THE STEERING OF BALLOONS.*

By Rudolphe Soreau.

After several years of laborious research, Commandant Renard, Director of our Central Establishment of Military Aeronautics, assures us that he is upon the eve of experimenting with a dirigable balloon capable of making evolutions in the air for about 12 hours, with a speed of its own of about 36 ft. per second, or 24.8 miles per hour. Therefore the dirigability of balloons is so far practically solved that it is believed the present occasion an opportune one for making a statement of the problem which has for a long time been condemned by official science, and against which there are so many prejudices. Furthermore, this question is interesting to the highest degree to the engineer.

THE CONDITIONS OF THE PROBLEMS AND ATTEMPTS AT STEERING.

As far as steering is concerned, the pretended conquest of the air is nothing but a word, for the balloon carried about by the aerial currents at the whim of their caprices is rather a prisoner than a conqueror of the elements. Man, too, has attempted to steer the balloon from the very day on which he discovered it; but up to recent times all attempts have been in vain. Must we conclude, then, according to the formula which has been taught us for so many years, that there is no point of support in the air? I think that it would be useful to lay down these conditions now, a knowledge of which will permit us to seize upon the value of attempts which have been made, and to see in what way it is proper to look for progress.

CONDITIONS OF THE PROBLEM.

Theory of Speeds and Characteristics of the Dirigable Balloon.—From a mechanical standpoint the dirigable balloon differs from the ordinary balloon by the individual speed with which it is itself operated. Let us define in just what this difference consists, and for that purpose let us suppose that two balloons are side by side at the point P, figs. 1 and 2. While the ordinary balloon driven by the wind would pass from P to X, and would be, at the end of a unit of time, for example, at the point of O, the dirigable balloon would traverse the line $P\ M$, so that the straight line $O\ M$ would be equal to its own speed and parallel to the direction $A\ B$ of its axis. When this direction changes, the point M describes a circumference about the center O, which constitutes the location of the points which the dirigable balloon, after starting at P, could reach in a unit of time.

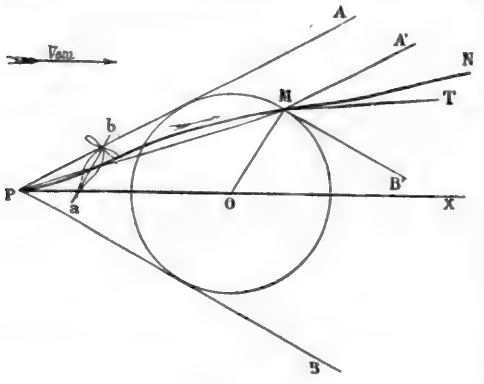


Fig. 1.

When its own speed, v, is less than the speed V of the wind, fig. 1, the direction $P\ M$ is necessarily comprised within the angle $A\ P\ B$, half of which has for its *sine* $\frac{v}{V}$. In this case, if the balloon changes its direction in starting from M, the new direction is still comprised within the angle $A\ M\ B$, all sides of which are parallel to those of the preceding angle; consequently the dirigable balloon can only follow the course $P\ M\ N$, so that the tangent $M\ T$ at any point whatever makes an angle with the direction of the wind, whose *sine* is less than $\frac{v}{V}$.

* *Mémoires de la Société des Ingénieurs Civils.*

On the other hand, if the speed v is greater than V, fig. 2, the route must be within the points of the circumference which can be inscribed about the point of departure by the straight line $P\ M$ in one direction or another. Inversely the balloon can describe a curve, which closes on itself if v is greater than V, and consequently it can follow whatever route may be desired. This, then, is the characteristic of the dirigable balloon. From what precedes it results that the steering of balloons is first of all a question of speeds, and to know what chances we have of taking a balloon, which has a given speed, in every direction, it is evidently sufficient to consult a table of the probability of the winds. Below we give an extract of this table for our regions:

Speed.	Probability of having a wind less than the given speed.
8.2	.10
16.4	.32
32.8	.70
65.6	.96
98.4	.995

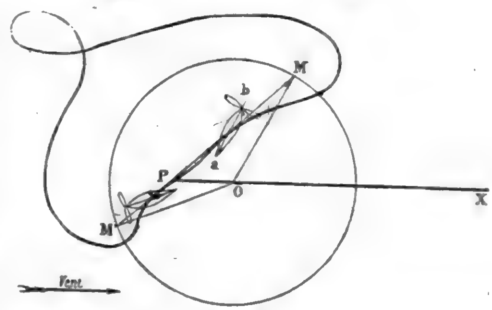


Fig. 2.

The new dirigable balloon at Chalais-Meudon can come back to its point of departure about three times out of four, the ascensions having been made absolutely at haphazard. We would remark, furthermore, that the speed and direction of the aerial currents change with the height and circumstances, which can be utilized for increasing the running speed, and even to help it on when the speed is less than that of the wind at points access to which would be impossible with the single current. Under these conditions we see that a speed of 36 ft. is usually quite sufficient. With a speed of 65.6 ft. it will be possible to go wherever you choose, except where the winds are violent enough to blow the roofs from houses. I would add that the aeronaut carried along by aerial currents at their own speed only perceives a storm by the rapidity with which the earth dashes along beneath his feet. Such is the problem freed from the vague conceptions about it; but if we see the object which it is desired to obtain very clearly—to wit, a possible speed of at least 32.8 ft. for a sufficient length of time—half a day, for example—the means which would lead to the accomplishment of this result are less clearly defined. To determine these means, let us examine the special conditions inherent in the nature of the medium and the properties of the movable which is to displace it. The medium is an isolated fluid, and this is exactly what distinguishes aerial navigation from maritime navigation, to which it is not wholly similar. The ship, in fact, is plunged in the two fluids, and it uses one or the other to overcome the resistance as they together oppose its motion; the flyer has recourse to the speed of the wind; the steamship utilizes the reaction of the water upon its propeller. On the other hand, the dirigable balloon plunged in a single fluid must overcome the resistance of the air by the reaction of the air itself upon its propeller. Furthermore, while the ship moves in a horizontal plane, the balloon is subjected to a perpetual vertical instability which singularly complicates the difficulties of the problem. There are the same great differences between the case of the dirigable balloon and that of the submarine boat. The vertical instability is more annoying for this latter—in fact, the least variation of weight makes it move from its zone of equilibrium and either sink to the bottom or rise to the surface. We know, furthermore, that this difficulty of maintaining itself between two waters is the stumbling-block of submarine navigation. On the other hand, the aeronaut can only leave the fluid where he is moving by varying the loading of his balloon, so that in this case it is the load which gives a rapid and simple means of putting a check to the descent. On the other hand, the incompressibility of

water is favorable to the action of the propeller, which finds an effective point of support, while the aerial screw grinds around in a medium which is mobile to a despairing degree.

Lightness of Motor.—It is therefore necessary to develop a high horse power upon the shaft of the screw; but as the balloon requires at least 16 cub. ft. per pound to rise, we perceive that in order to construct a dirigable balloon it is necessary to obtain the power with a weight very much less than that which is obtained in motors of ordinary construction. The condition which controls the problem is the discovery of a motor which is at the same time powerful and light, and if one considers, as I shall show later on, that the work of development varies as the cube of the speeds, we will understand the absolute necessity in the actual state of the case not only of designing a light motor, but also of reducing to a minimum the resistance to advancement.

The Diminution of Resistance to Advancement.—To diminish these resistances it is evidently necessary to elongate the balloon in the direction of movement; but the effects of this elongation will only be felt if the material of which the balloon is constructed is perfectly extended, otherwise pockets will form on the front side at the point where the resistance is at the maximum, and the air, instead of sliding over the stuff, will strike against the concave arc in such a way as to increase the resistance twofold, compromising the stability and even being able to stretch the envelope into pockets between the framework.

But this is not the only condition which it is necessary to fulfil. Let us suppose a dirigable balloon whose axis coincides with the direction of movement when it is running at a predetermined speed. The motor being in the car, it is evident that if the system on which the car supporting portion of the balloon is constructed is not perfectly rigid, the suspending cords will not work evenly, but will vary as the speed changes, and the front end will lower or rise according as it runs slower or faster. This will occur when the axis of propulsion does not pass through the center of inertia.

If the system is perfectly rigid, this lowering or elevation is not produced, and there will be a most decided advantage. Let us suppose that the prow rises, the bottom of the balloon offers to the current more surface at the front end and less at the back; on the other hand, the gas is precipitated toward the front. For these two reasons the deformation of the system due to the variation of the speed tends to accentuate itself; but when the connection is rigid and the permanence of the shape assured, the system constitutes a kind of block; and as the center of gravity is always below the point of application of the ascensional force, it is sufficient for some oscillations to simply stop the screw. The up and down motion can also be produced by a cause which has not as yet received sufficient attention. I wish to speak of the vertical instability. If rupture of equilibrium occurs, which gives an ascensional

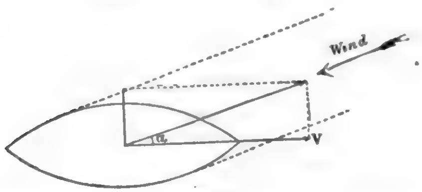


FIG. 3.

speed V (fig. 3), for instance, this speed is composed of the velocity V, and the resistance to advancement exercised along the line A, which augments the resistance very much, and may bring about serious complications with a long balloon. Now the inevitable escape of gas, the continual changes in the condition of the atmosphere, the variations of the solar radiation, etc., modify the vertical equilibrium at every instant. Instead of the usual rudimentary means, which consist of opening the valve and throwing out ballast, which only correct the displacement that has been produced, it is necessary that there should be some automatic arrangement which is still to be discovered. Furthermore, it is proper to remark that by increasing the speed proper we will increase the instability in a horizontal plane, so that the automatic arrangement desired is really very useful only at lower velocities, which will mark, for a number of years to come, the opening efforts at aerial navigation. It is clear that the car and the net ought to be such as to diminish the resistance to advancement. If any prime prescription is to be imposed in this regard, it is the importance of constructing every form with the greatest care. I will show further what an unsuspected part they play in the subdivision of the resistance. Finally, in order to determine what chances there are of overcoming the resistance to advancement, it is necessary independently of a light motor to have first an elongated balloon.

2. Invariability of form.
3. Rigidity of construction.
4. Vertical equilibrium.
5. A car and a frame of proper form and dimensions.

Certainty of Route.—All these precautions would be entirely without effect, unless we can be sure of the certainty of the route. It is necessary, then, to still add some new and important conditions to those which have just preceded. An attempt is made to obtain certainty of route by the assistance of a rudder, which is a simple means of modifying the direction followed. It is clear that the rudder, whatever may be its dimensions and its distance from the vertical which passes through the center of inertia of the system, would be powerless if the resistance varied at every instant. Such would be the case of a dirigable balloon which was incompletely inflated. Thus the permanence of form ought to be considered as a means not only of diminishing the resistance to advancement, but especially of assuring the efficiency of the rudder.

The balloon should be maintained constantly inflated, lest it may not escape the frequent giratory movement of the ordinary balloons, if it has the spherical form of the latter—in fact, the slightest variation which destroys the symmetry of this shape would suffice to cause a rotation about the axis. The elongation of the dirigable balloon, while it reduces resistance, at the same time permits a route to be determined by diminishing the frequency of the giratory movements, and thus increases the efficiency of the rudder, which is some distance from the center of inertia.

Thus the certainty of route is obtained by conditions already determined. Sometimes these conditions are not always sufficient, particularly when the relative speed changes frequently. It then causes swervings and turnings against which the rudder remains powerless. I hope to be able to show how it can contribute, by its own form, to insure the stability of its running.

If I add that the larger the balloon, the greater are its chances of becoming dirigable, then for two balloons which are geometrically alike the ascensional per unit of form is greater for the large balloon; and, on the other hand, the weight per horse power diminishes with the force necessary to be given to the motor. The principal conditions which ought to control the construction of dirigable balloons are grouped in the following table:

Lightness of motor.... Diminution of resistance to advancement..........	Elongated balloon. Invariability of forms. Rigidity of construction. Vertical equilibrium. Car and netting of convenient shape and dimensions.
Certainty of route....	Elongation of the balloon and rigidity of construction. Rudder. Shape of balloon.

(TO BE CONTINUED.)

JAPANESE RAILWAYS.

THE following interesting account of railways in Japan has been received from a very intelligent correspondent in that country:

Japanese railways are now making good progress, and throughout the empire there are now about 1,500 miles of railways in working. The first government railway in Japan is Tokyo-Yokohama section, the length of which is 18 miles. In 1870 the survey for that line was made, and in about two years the railway was nearly constructed, and, in the mean time, the line was opened. In May, 1872, the whole line was completed, and on September 12, 1872, it was opened in the presence of His Majesty, the Emperor. Then after ten years about 100 miles of railways were constructed and working. Private companies were gradually formed, of which the Niphon Railway Company is the first and largest. The company was established on November 11, 1881, and the line for the first section (38 miles long) was opened on July 21, 1883. The following figures will give some account about the present condition of the company: Subscribed capital, $20,000,000; paid-up capital, $18,599,100; average daily income (for latter half of 1892), $7,332.27; miles in working order, 591 miles, 61.5 chains; number of locomotives, 67; number of passenger cars, 209; number of freight cars, 1,014.

The interest distributed to shareholders of the company is

at least 10 per cent. per annum, and the stock of the company costs nearly double of the paid sum.

The line of the Niphon Railway Company extends from Tokyo on one side to Maebashi, which is the center of silk districts in Japan, and on the other to Awomori, which is an important harbor situated on the northern extremity of Honshin (or the main island). From the latter line there is a branch to Nikko, which is famous for beautiful natural scenes and splendid temples, being remains of shrines of ancient Shōgun Tokugawa.

Besides the Niphon Railway Company there are other companies, known as Sanyō, Kiushin, Kansei, Sangū, Iyo, Isaka Hankai, Kōbu, Ryōmō, Mito, Sōbu, Tankō railway companies, etc., having their lines from 20 to 200 miles long.

In addition to the lines already completed and working, there are projects both in government and private railways to prolong the lines. Since last year proposed new lines of more than 2,000 miles in length were surveyed and estimated. It was decided by the House of Commons to construct the Fukushima Awomori section and the Tsuruga-Toyama section, which has 414 miles in both. The capital for constructing the two lines decided by the Parliament is $18,451,080, which is the amount decreased about 20 per cent. from the estimates made by the government engineers. These railways are, of course, important for internal communications and transportations, and will be very much more so if the Siberian Railroad would be completed.

The gauge of Japanese railways is 3 ft. 6 in. The steepest gradient is 1 in 40, and the shortest curve is 15 chains radius. For the Usui toge Railway, between Yokokawa and Karuizawa, in Takasaki and Naoyetsu section of the Imperial Government railways, the Abt system of permanent way was adopted, and the gradient is mostly 1 in 15. The length of the Abt system of permanent way in that section is 5 miles 6 45 chains, in which there are 26 tunnels from 107 ft. to 1,803 ft. long, the total lengths amounting to 2 miles, 61.882 chains. This section between Yokokawa and Karuizawa (7 miles long) was completed in February of this year, and it was opened for traffic on the first of last April, while the sections on both sides of Usui-toge were opened eight years ago.

The weight of the Abt system locomotive is 35 tons, which can draw 100 tons of loads in the steep incline. Most of the locomotives of Japanese railways are of English manufacture, but some American and German locomotives are used. There are also locomotives of Japanese make, which were built in the Kōbe Locomotive Works of the Imperial Government railways.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

II.—METHOD OF DETERMINING CARBON IN IRON AND STEEL.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page 399, Volume LXVII.*)

The double chloride of copper and potassium solution is made by dissolving 10 lbs. of the commercial salt in 13 liters of water, filtering through ignited asbestos, and adding 1 liter of concentrated C. P. hydrochloric acid (sp. gr. 1.20).

The caustic potash solution used both in the purifying potash bulb and the absorption potash bulb is made by dissolving 1 lb. of commercial stick caustic potash in a small amount of water, and then diluting until the resulting liquid when cold shows a specific gravity of 1.27. A pound of potash makes about a quart of solution.

The granulated oxide of copper may be made by igniting the nitrate in a Hessian crucible until nitrous fumes cease to come off, but not fusing the material, or may be obtained in the market. If the ignition of the nitrate is properly conducted, a porous granular material is obtained, which gives very satisfactory results. Most of the material in the market has been fused and is very dense, and liable to contain impurities. We regard it essential, therefore, to place this fused material in the preheating and combustion tubes, as described, fitting them at the exit end with a small jet tube, then place in the furnace and reduce with hydrogen gas. It is essential during the reduction that the tube where the oxide of copper is should be heated to a full red heat, and in order to insure complete reduction, the gas should be passed for half an hour after it will burn at the jet. This being accomplished, allow the tube to cool and then replace the hydrogen with air, then heat up again, and pass oxygen gas until the reduced material is oxidized, which will take some time. The use of coal gas in place of hydrogen for the above reduction is admissible, provided the porcelain tube is heated two burners more each way, during the subsequent oxidation, than during the reduction in order to burn out any separated carbon that may have deposited in the tube.

The silver foil may be easily obtained in the market.

The acid ferrous sulphate solution is made by dissolving crystallized ferrous sulphate in water to nearly a saturated solution, and adding three or four drops of sulphuric acid to every 50 c.c.

The sulphate of silver is made by precipitating nitrate of silver with carbonate of soda. Filter and wash thoroughly. Then place the precipitate in the vessel in which it is designed to keep the salt with a little water, and then add sulphuric acid at last, drop by drop, with thorough agitation, until all the carbonate is decomposed and the liquid is clearly acid to test paper. In filling the bubble tube shake the vessel and pour in enough of the milk to have ¼ in. of the solid salt in the bottom when it has settled, and then fill the bubble tube about half full of water. If care is taken to wash the carbon in the boat thoroughly, once filling of the sulphate of silver bubble tube will be sufficient for 30 or 40 combustions. Sulphate of silver may be obtained in the market, but we have no experience with this material.

The granulated chloride of calcium used in the chloride of calcium tubes and prolong is obtained in the market. We use the grade marked C. P., and like to have it as free as possible from other substances. The size we prefer is what will pass through holes about a tenth of an inch square and not pass through holes a twentieth of an inch square. Before filling the chloride of calcium tubes it is essential to dry the material, best in a platinum dish over a Bunsen burner for 20 minutes or half an hour, taking care, however, not to fuse it. Of course the chloride of calcium used should not be alkaline, but for fear that it will be sufficiently so to absorb carbon dioxide, even if not sufficiently so to show by test, it is recommended to pass dry carbon dioxide into each freshly filled chloride of calcium tube and allow it to remain over night, and then replace with dry air, before using such tubes in actual work.

The oxygen gas used may be obtained in the market in cylinders compressed to almost any desired pressure. We transfer to the small gas holders shown in the cut, rather than take the gas direct from the cylinders, since the gas holders can be adjusted to give uniform pressure in the tube. This commercial material may be contaminated by oil or vapors containing carbon from the pump used in compressing it, and we accordingly deem it essential to pass it through the preheating tube, as described, before it goes into the combustion furnace.

After the combustion train is arranged, as above described, it is essential to see that there are no leakages, and to make not less than two blank combustions. For the first of these, close the connection from the gas and air holders, and then open the cock controlling the flow from the aspirator bottle, which has been previously filled with water. This puts suction of a column of water 12 to 18 in. high on the train, and is abundant to indicate any leaks. After the suction has had time to act on the whole apparatus, and come to rest, it is satisfactory if nothing passes the absorption potash bulb for five minutes. If this result does not follow, the leaks must of course be found and stopped. The combustion train being found tight, the two blank combustions should be made in every respect as though they were real ones, except, of course, no iron or steel should be put in the dissolving jar. If these blanks change the weight of the absorption potash bulb and prolong more than about 1 milligram, something is wrong, and the apparatus and chemicals should not be regarded as satisfactory, until one or more blanks are obtained, which come within the limit above mentioned. In this connection the paragraph below on necessary errors should be read.

CALCULATIONS.

Since the carbon is weighed as carbon dioxide, and since $\frac{3}{11}$ of the carbon dioxide is carbon, the percentage of carbon in the iron or steel under test may always be found by the fol-

lowing formula : $a : 100 :: \frac{3}{11} b : x$ in which a represents the amount of iron or steel taken, expressed in grams ; b the increase in weight of the absorption potash bulb and prolong expressed likewise in grams, and x the carbon sought. This proportion reduces to the form $x = 300b \div 11a$, and when 3 grams are used to start with, it becomes $x = 100b \div 11$. When 3 grams are taken to start with, this may be briefly stated as follows : Express the increase in weight of the absorption potash bulb and prolong in grams, move the decimal point two places to the right, and divide by 11. The result will be the percentage of carbon in the sample. Thus if the increase in weight is 0.1661 gram, the carbon will be (16.61 ÷ 11) 1.51 per cent.

NOTES AND PRECAUTIONS.

It will be observed that this method releases the carbon from the iron or steel by dissolving the metal in an acid solution of the double chloride of copper and potassium; and after filtration and thorough washing burns the carbon in a tube in oxygen gas, and after freeing the carbon dioxide formed from impurities, catches it in caustic potash solution, the amount being determined by the increase in weight of the absorbing material.

There is much reason to believe that many discrepancies in duplicate analyses, as well as between different chemists, are due to the borings or drillings. The place from which the drillings are taken ; the size of the drill ; the depth of the hole ; whether it goes through the sample or not, and especially whether the drillings are partly coarse and partly fine, are all believed to have considerable influence on the final result. This difficulty will be diminished (1) by drilling the hole as near through the sample as practicable ; (2) by having this hole transverse to the line of final solidification, and cutting it, and (3) by having the drillings as fine as possible, and thoroughly mixing them. This latter precaution—viz., to have the drillings fine, is also important in its influence on the rapidity of subsequent work.

The use of acid, and the use of the potash double salt, rather than the ammonium double salt to dissolve the metal, both of which differ from old practice, are copied from the work of the American Committee on International Standards, for the analysis of iron and steel. It will be remembered that the work of this committee seemed to show very conclusively that these changes led to much more accurate results.

If the solution contains more of the double salt than is recommended above, solution will not be so rapid. A saturated solution works very slowly.

The influence of stirring on the rapidity and completeness of solution is very great. With the stirring apparatus recommended above, if the borings are fine it is not at all rare, especially in the case of steels, to get such complete solution in 15 to 20 minutes that but little more than a stain is left on the asbestos filter in the boat after the combustion is finished.

In washing the carbon in the boat, after it is transferred from the beaker or dissolving jar, loss of substance is apt to result, if the jet from the wash bottle is used direct. It is better to always put the liquids into the beaker or dissolving jar, and then pour them into the boat. Too great care can hardly be taken to wash thoroughly. A little sub-chloride of copper or a little chloride of iron left in the asbestos filter, or in the boat, may cause difficulty in the combustion tube later on.

The carbon from some steels, and in general from pig iron, filters readily like sand, but from other steels it seems to separate in such a form as to clog the filters badly. This gelatinous carbon does not seem to be characteristic of any special kind of steel, but may occur in any. We know of no way to facilitate filtration in such cases, except to follow the directions closely.

In drying the carbon in the boat too high temperatures should be avoided. There are indications that loss of substance may result from neglect of this precaution, although we have not positively demonstrated this.

The use of the preheating furnace complicates the train somewhat, but no other method of freeing the oxygen gas from possible injurious impurities has proven so successful in our experience as this one. It is clear that if there is anything in the gas that would react with oxygen or with oxide of copper in a red-hot tube, and later be absorbed by caustic potash, this material must be removed from the gas by the preheating furnace and purifying potash bulb before the gas goes into the combustion tube. Purifying the oxygen gas without preheating does not seem so satisfactory.

The use of rubber corks and rubber tubes is open to some objection, but we do not know of any successful substitutes for these materials.

The combustion tube we recommend is longer than customary, but we think not longer than essential. The danger of volatile matter from corks affecting the result is considerably diminished by this additional length. We prefer the porcelain tube, although we have never used platinum ones. Tubes of larger bore enable a little larger boat to be used, but they are much slower to heat, and do not in our experience give any more reliable results.

The use of a roll of fine copper gauze in the combustion tube in place of granulated oxide of copper has been recommended. In our experience it is difficult to be sure that the metallic copper is all oxidized before regular work is begun. If this is not so, and if the metallic copper contains any carbon, there would of course be danger of error, due to the slow progressive oxidation of the metal and carbon during combustion.

Many devices have been suggested to prevent the possibility of hydrochloric acid, chlorine or chlorine compounds, which may be formed in the tube during combustion from reaching the absorption potash bulb and thus introducing error. We have tried many that we have seen suggested, but have found none that seem so efficient as the roll of metallic silver foil. If proper care is taken in the washing of the carbon, if the tube is arranged as described, and in good order, and if the rate of movement of the gases is not too rapid, neither chlorine nor hydrochloric acid escape from the tube. If, however, the washing is incomplete, leaving some sub-chloride of copper or ferrous chloride and free hydrochloric acid in the boat, which latter is not expelled by the drying ; if the tube is foul from having been used for many combustions, without cleaning and recharging, or reduction by hydrogen, and especially if the combustion is hurried, resulting in a too rapid movement of the gases in the tube, the silver roll may not be a complete protection. We accordingly introduce into the train an acid ferrous sulphate, and a silver sulphate bubble tube as additional precaution, the former to catch chlorine and the latter hydrochloric acid. Direct experiments with each of these tubes separately show that they are a complete protection against the gases mentioned, provided the rate of movement is not more than four or five bubbles a second, and also provided the amount of these gases is not greater than would arise in even the rather carelessly managed combustion mentioned above. Of course it may be questioned whether these two bubble tubes do not retain carbon dioxide and thus cause error. Direct experiments made by taking a weighed potash bulb and prolong, properly filled with water, protecting it with chloride of calcium tubes at each end, and charging it full of carbon dioxide, and reweighing and then aspirating air through it with frequent weights during the aspiration show that a very much less amount of air than that used for aspiration in a regular combustion is sufficient to remove the carbon dioxide completely from the amount of liquid in the bubble tubes.

It is highly desirable to pass hydrogen or coal gas, preferably the former, through the combustion tube, as described above, after a tube has been used for 50 or 60 combustions. In lieu of this, the tube should occasionally be cleaned out and filled with fresh material. The frequency with which either of these should be done depends largely on how completely the carbon is freed from other substances during the solution, washing and drying.

A slight pressure in the tube is thought to be less liable to lead to error from leakages than to have a vacuum in the tube, caused by drawing everything through the train by means of the aspirator bottle. It will be observed that the pressure specified is equal to about half the column of water in the first bubble tube. From this point the aspirator bottle is relied on to move the gases forward.

The combustion tube should always be kept closed, and after a combustion is finished, the connection between the air gas-holder and the train should be left open, or the liquid in the bubble tubes will suck back into the combustion tube as it cools. We also deem it essential after the furnace has been standing idle some time to make a blank before proceeding with regular work in order to be sure that everything is right.

It is quite essential that the chloride of calcium tube which precedes the absorption potash bulb and the prolong should dry the gases to the same extent and no more. If one is more efficient than the other error may result. Thus if the gases which go into the absorption potash bulb are drier than they are after they leave the prolong, it is obvious that moisture that has been weighed is lost. On the other hand, if the gases that go into the absorption potash bulb are not as dry as when they leave the prolong, it is equally obvious that something besides carbon dioxide has increased the weight of the absorption potash bulb and prolong. It seems probable that some of the difficulty in getting absolute blanks may be accounted for in this way. It is a little hazardous to use a freshly filled chloride of calcium tube with an old prolong, and *vice versa.*

Likewise it is not advisable to use sulphuric acid or other means of drying the gases between the furnace and the chloride of calcium tube.

It is not necessary to recharge the absorption potash bulb for each combustion. Depending, of course, on the amount of carbon in the sample, they may be used for from three to six or eight combustions without recharging. We have made agreeing duplicates on the same sample, one with a potash bulb, freshly charged, and the other with a potash bulb, showing a cloudiness in the first bulb due to bicarbonate.

The weight of the potash bulb and prolong before and after the combustion is affected by a number of circumstances other than the carbon dioxide absorbed. It is obvious that if all the conditions are the same at the second weight which prevailed at the first, there is no error due to weighing. But it seems to be difficult to get these conditions exactly the same. Temperature, barometric pressure, the deposit of something from the air of the laboratory, or from the fingers on the parts weighed, and especially the humidity of the air may all be different at the second weighing than at first. If we may trust our experience, it is almost impossible to make satisfactory combustions in showery weather.

Where combustions are made in large numbers, say 16 to 18 a day, by one operator, with two furnaces, very satisfactory results may be obtained by weighing direct from the furnace, finishing the aspiration with oxygen instead of air, and using the last weight of one combustion as the first weight of the next one. Of course in very critical work this procedure should not be thought of.

Direct experiments show that with the apparatus arranged as above, the oxygen in the potash bulb and prolong is all removed by air during aspiration, when about 800 c.c. of water has been run out of the aspirator bottle. The experiments were made by weighing a potash bulb and prolong, introducing it in the train, passing oxygen until it was filled, then reweighing and then aspirating air with frequent weighings until the first weight was obtained.

If the aspirator bottle is fitted with a tube reaching nearly to the bottom, as shown, the suction on the train will be the same irrespective of the amount of water in the bottle, until the bottom of the tube is reached.

Notwithstanding all precautions, there seem to be some almost unavoidable sources of error in the combustion method of determining carbon. Among these may be mentioned the possibility of hydrocarbon vapors from the rubber tubes and corks, the unequal drying of the gases by the chloride of calcium tube and prolong, the difficulty of getting absolute blanks, and especially the difficulty of making the second weight, under exactly the same conditions as prevailed when the first one was made. We do not think all these errors combined should amount to more than one or two hundredths of a per cent. of carbon.

USES OF METALLIC TIES.

By A. Flamache.

Every engineer has been struck by the extreme variation of opinion concerning the use of metallic ties on railroads. Some, such as the English railway companies, the great majority of French managers, the Belgium State Railway, and as a general thing the managers of the lines of Western Europe, where the traffic is very heavy and fast, are systematically opposed to the use of metallic ties. The rare applications on the lines which have just been cited are the result of absolutely outside causes, such as the powerful influence which could be brought to bear upon an English road, which was soon compelled to remove these ties, in spite of its desire to please the inventor. Sometimes it is in order that the inventive faculty of the officers of the company might not be discouraged, that the latter consents to use a few ties which were designed by their engineers. Sometimes the railroad company which handles the freight of an important steel works buys a few tons, and pays for them by transporting raw material. More often still, it is a governmental movement, which, in a moment of distress, does it in order to make work.

In all this there is no such infatuation as metallic ties have inspired in Germany and Austria, where engineers seem to have considered the question as solved. It is true that they formerly manifested the same inclination to use metallic stringers, which are now used by a few managers only who are more or less interested, as inventors, in their success. There is, nevertheless, some singular facts arising from this divergence of opinion. How can it be that a system of tracks, which lasted only eight days on an English line, such as the Haarmann, which was made in two pieces, has been tried and lasted for several years on certain German lines?

Many, however, are agreed that when the metallic tie has reached a firm basis, its maintenance is far less expensive than that of a wooden one; while others, resting upon 20 concurrent results obtained in different sections, declare that the maintenance of the metallic tie is twice and a half or three and a half times as expensive as that of the wooden one. These great differences of opinion between men of equal ability and indisputable veracity are not inexplicable.

The object of the present article is to lay down a few observations which I have had occasion to make, and which, if they do not throw any definite light upon the subject, may lead at a later time to a complete knowledge of the truth. All the differences of opinion which have been produced are derived from the fact that hollow ties, with opening turned down, have invariably been used upon lines where the work is very heavy, and that the maintenance of these ties was very expensive, while upon lines where the traffic was light, they have been easily maintained. This fact being recognized, I have proceeded into the examination of different metallic ties, with hollow supports of different shapes, and have watched the metallic track very attentively where it had to be reconstructed and put in good condition. The passage of trains upon supports which have edges vertical or nearly so has an effect of forcing these edges down into the ballast and then withdrawing them, according as the tie descends or ascends with the wave motion of the rail. However hard the fragments which composed the ballast made may be, they are worn out, and form a sort of mud, which fills the interstices, and transforms the ballast contained in the open part into a very hard macadam, which is more or less hard upon its edges. At the same time the volume occupied by this diminished ballast is obliged to flow again in order to maintain the tie at its proper height. That is the first period for the maintenance of metallic ties observed by everybody, and recognized as being particularly difficult even by the advocates of metal, but not being likely, according to them, to last more than a few months. Starting from this point, the tie is seated upon a hard core, is anchored by its lower portion into the sub-adjacent ballast, and is absolutely immovable. At the first the track is excellent except that it is a trifle hard, but at the end of about a month accidental causes intervene either under the action of the vibrations, caused by the passage of trains or to the wave motion, or by a deformation of the roadbed, the cores are displaced and carry with them the lower portion of the sub-adjacent ballast. The tie embedded in this core is displaced with it, and the track soon presents a series of sags, not very deep, it is true, but still of a very disturbing character. At the same time the distance between the centers of the ties is changed, and some of them are brought into an oblique position with the rails.

Such is the condition of all the German railways which I have examined. As long as the speed of the train does not exceed 47 miles to 50 miles per hour, these sags have no other disadvantage beyond that of shaking up the passengers pretty badly, but without putting their lives in danger; but when a speed of 62 miles or more per hour is obtained, the situation becomes unendurable, and must be remedied at any cost. A difference of from 6 to 12 miles in the speed modifies the whole running of a train. In experiments which I have made with my deflectograph I have seen a train of passenger cars, hauled by an excellent engine, admirably balanced, running at different speeds over a new and thoroughly good track, take a sensible deflection and balance upon its springs at 56 miles per hour, and while it was in that position remain exempt from all other movements. Further on, at 62 miles per hour, the swaying was very annoying upon a less perfect track, and the strain, as shown by the instrument, was double that observed at 44 miles. Upon a poorly ballasted or tamped track the train reaches a disturbing speed more quickly and in a more pronounced manner, and engineers of lines where rapid express trains are running ought to keep their tangents in true alinement, both vertically and horizontally, lest they cause disastrous derailments or destroy in the course of a few years the best built track.

No one believes that a few blows of the tamping-bar or pick is sufficient to obtain a perfect dressing of a track with hollow ties. A track which is thus brought to alinement is forced back to its old position by the first train which passes, each tie falling back upon the core which sustains it. To obtain a suitable dressing, the old core should be demolished and the tie tamped up afresh; then the period of expensive maintenance begins, which we pass as soon as the cross-ties are well seated, and which follows at once a greater or less intensity of traffic. Is it not plain, then, that where one is contented with a poorly tamped track the hollow tie can only lead to fresh ex-

penses? This will be the case on all branch lines or main lines where the speed is not in proportion; therefore where the necessities of traffic oblige rapid running, it is necessary, at any odds, that the rail should be often brought back to alinement, and then the maintenance will be expensive.

I have already said at the Exposition of Metallic Ties, organized by the Society of Engineers of Brussels, that the metallic tie ought to be seated upon the ballast by a flat surface, or at least one which does not require a tamping up into a hollow. Furthermore, it is undesirable that the tie should have any other form than that of a strictly prismatic one; that it should have any curvature or bendings, or that it should be furnished with bosses or riveted joints. On these conditions alone its longitudinal or transverse displacement would be possible without the disturbance of the ballast foundation—that is to say, without deforming the seating which has been acquired with so much difficulty after months of travel.

On the French lines the truth of this was very clearly manifested, and it has been more or less recognized as one of the conditions of the maintenance of the metallic tie. The experiments heretofore attempted by French engineers have been very unfortunate, because inventors have had recourse to riveting in order to obtain the resistant profiles and plans.

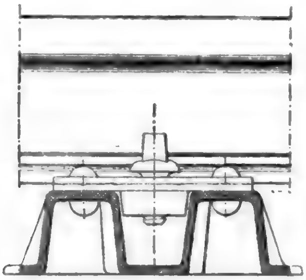
A new outline has been proposed in France and is obtaining a wide application. It is the Bernard & Ponsard types. The pressure cores formed in the two canals are adherent to the tie, and move with it. In consequence of the relatively small hollow and the slight inclination of the sides, these cores form a sort of filling, which moves in every direction with the tie. The bending, however energetic it may be, does not attach them to the sub-adjacent ballast.

The result is that this profile is practically the same as that of a tie with a flat support. It is displaced in any direction just the same, and it does not wear out the pieces of the ballast, because there is no friction of its edges against them.

Ties of this type placed upon a very heavy traffic line gave, when examined at the end of 1889, a perfectly straight track. Not only could they be displaced like any other, even one of wood, but the tamping could be done quite as easily as with the latter and fully as certainly.

It is greatly to be desired that the French railway should extend the use of this outline, and I am not surprised that the results obtained are totally different than those furnished by the hollow outline.

Aside from the remarkable tests of Bernard & Ponsard, I do not know of any serious attempt to secure this plane surface of support. I eliminate at once as impossible the ties of U shape with the concave surface upward.



BERNARD & PONSARD.

In fact, the rail could only be attached in two ways: by supporting on the edges, which would invariably cut it, or by interposing a block of wood or a shoe of cast iron between the rail and the bottom. Experience has shown that these double attachments do not wear long.

Furthermore, the U-tie, in whatever manner it may be put to work, presents a capital defect in its slight resistance to deflection.

The cross-tie of a railway is deflected by a very considerable moment. It is, in effect, from the standpoint of deflection equivalent to a piece resting upon two supports and strained by force more or less equally divided. The best filling is that which extends uniformly from the end of the tie toward the center, a distance from the rail equal to that which separates this latter from the end. It can easily be estimated without any exaggeration that the tie of a heavy traffic line ought to resist about 2,506.6 foot-pounds. This is a figure which I have adopted for special use, and nothing has yet been shown which influences me to change it. It may be objected that it presupposes the load carried upon a single tie; but my experiments have shown that this is often the case. If it is remarked that the additional loads due to dynamic actions are neglected—that is, excessive weight on springs, the rolling around a longitudinal axis, the centrifugal force in a vertical plane due to a passage over a curve, we see that the above figure will often be practically exceeded.

There is but a single cause which may diminish its importance. By tamping the tie very strongly under the rail and not so much at the ends and at the center, it is evident that the maximum moment becomes less, but there results an excessive pressure upon the ballast which deforms it until the surface of support reaches proper proportions.

In conclusion, I repeat that a moment of 2,500 foot-pounds can be counted upon as the strain of a tie on a heavy traffic line. The U form of section, as we have said, is not the thing at all from the standpoint of deflection. If we look for the deflection of a tie of this outline, which weighed 172 lbs., we find that it corresponds with a moment of 2,500 foot-pounds to a strain on the metal of 38,386 lbs. per square inch.

It is easy to see that these disastrous conditions of resistance to deflection are irremediable with the U form where the neutral axis is from 4 in. to 8 in. from the bottom. The moment of inertia is, therefore, weak, and for a given height of outline the distance of the neutral axis from the line of maximum strain is increased. In ties of symmetrical outline, the neutral axis passing through the center of the height, we obtain a weight that is in the best possible shape for the resistance to deflection.

The slight resistance of the hollow tie places the engineer between two equally bad alternatives—either he must tamp the tie exclusively under the rail, and, in this case, the tamping will not last and the maintenance will become very difficult and expensive, or he must tamp the whole length, and the tie will break.

It is evident that this rupture will occur at the bolt holes, and, unfortunately, almost all these systems require that their rectangular holes shall be made with a punch, which so modifies the structure of the metal at its edges that it causes defects which sooner or later cause a rupture of the sections. Everybody knows that steel when treated in this brutal manner becomes weakened. It may be well to repeat here again that these disadvantages are not particularly felt on lines where the traffic is not heavy. Several years might be necessary before they would appear. The result of my observation is that a hollow cross tie weighing from 154 to 172 lbs. can support, before breaking, the passage of from two to five million pairs of wheels, according to the running speed. This figure is easily reached in from three to four years on heavy traffic lines, but may demand ten or a dozen years on branch lines. That is why hollow metallic ties on German and Dutch lines seem to sustain the traffic so well, and that they are not put out of service in a few years, but last until their normal life has been passed.

The first breakage is the signal for a general clearing out time, and the German managers pay very dearly for their impulsive desire to use metal ties.

In *résumé*, the metal tie for heavy lines can only be used under the following conditions:

1. It should not require tamping into a hollow space—that is to say, it ought to be able to be displaced longitudinally and transversely, like a wooden tie with a flat bottom. It is also bad to give it any curvature bosses or variations of section, or to furnish it with stamped projections or riveted joints. Its form should be strictly prismatic.

2. It ought to weigh from 165 to 175 lbs., and be formed of steel in order to offer a moment of resistance of from 5,450 foot-pounds to 5,800 foot-pounds. Iron of the U form is not strong enough in any position, as it is a shape unfavorable to deflection, and it ought to be excluded. The outline ought to be symmetrical.

3. The resistance ought to be obtained in full outline—that is to say, the riveted joints ought to be excluded.

4. The attachments ought not to require rectangular holes, but the only holes made should be made drilled, and these are preferably round.

This outline only relates to metallic ties for main lines, and, in my opinion, it is the only one to which any attention should be paid at this time on the railroads of Western Europe. In these countries, in fact, the important lines represent a greater portion of the total trackage; and the new material ought to be laid in preference to the use of old, which, when half worn out, should be taken up and relegated to branch lines, as there is almost always some of this material to be used that has been taken from the main lines, for it is very convenient to be able to place it on branch lines where its life would be considerable. Thus, the 500 miles of the double track road of the Belgium State Railway supplies sufficient material for the main-

tenance of 15,000 miles, of which 10 per cent. is double track belonging to the branch lines of the system.

In countries where this state of affairs does not exist the population is sparse and the forests are abundant ; metallurgy is not very much developed, and the wooden tie reigns absolute mistress of the situation.

It is, therefore, in vain to look for the introduction of metal ties of any existing type into the colonies ; but the situation might be changed if we could find a metallic tie that is movable and possesses the qualities of great durability under the most rapid trains. If this discovery should appear to-morrow it would realize the hopes of metallurgists, and the duration of the material would be such that there would be more than enough material left over in the case of important tracks for the maintenance of branch lines. Consequently the new tie would come into use upon these latter lines, and, as at these points metal can struggle most advantageously against wood, there is nothing impossible in the fact of iron becoming everywhere triumphant. Therefore, it is in the direction of metallic ties for heavy traffic lines that inventors ought to turn their attention if they desire to obtain control of Europe.

It is also in this direction that experiments ought to be pursued by the governments of the metallurgical countries where the metallic tie would be of very general interest. Far from attempting at the last moment to give some constrained and forced orders to an industry that is on the verge of a crisis, it ought to test every new type that appears which promises to be able to withstand a heavy traffic. The smoothness of the supporting face and strong resistance to deflection are the most important conditions. In my opinion the tests of weak or hollow ties, though made by managers with perfect good faith, can only yield fruitless results.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 342.*)

In the opinion of the writer of these lines Herr *Lilienthal* has attacked the most difficult, and perhaps the most important, of the many problems which must be solved before success can be hoped for in navigating the air with flying machines. He has engaged in the effort to work out the maintenance of equilibrium in flight, and to learn the science of the bird. He has made a good beginning, and seems to be in a fair way to accomplish some success in riding on the wind.

We have already seen that this has been tried before, and that (to say nothing of ancient myths) *J. B. Dante*, *Paul Guidotti*, *Francisco Orujo*, and Captain *Le Bris* all met with partial success in soaring. Singularly enough all four met also with the same accident—*i.e.*, a broken leg, in consequence of the loss of equipoise. Herr *Lilienthal* has greater chances of success, not only because he seems to have set about his experiments only after thorough investigation and consideration, but also because mechanical knowledge as well as constructive methods and workmanship have greatly improved since even *Le Bris's* time. Besides this, we have the gliding exploit of M. *Mouillard*, whose experiment has already been related, and that of M. *Ader*, which is yet to be mentioned.

Most of the capable inventors who have undertaken to solve the problem of flight have first concerned themselves with the question of motive power, and we shall see hereafter that very great progress has been achieved in this direction since 1890 ; but no amount of motive power will avail unless the apparatus to which it is applied is stable in the air—unless it can rise, sail, and come down again without danger of losing its equipoise. As has already been said, safety is the first requisite, and until this is assured, all the other elements of success will be unavailable.

Herr *Lilienthal* has eliminated for the present the question of motive power, by undertaking to utilize ascending trends of wind, like a sailing bird ; and if he succeeds in gliding up as well as down, and to the right or left, and in maintaining at all times the coincidence of the center of gravity with the center of pressure at all angles of incidence, he may not only apply an artificial power hereafter for use when great speed is required or when there is no wind, but he will also probably have evolved a method of gratuitous transportation through the air when the wind blows under proper conditions ; for there seems to be no good reason why a soaring apparatus for one man should cost more than twice as much as a first-class bicycle, or half as much as a city carriage ; and when the wind is in the right direction, a good many miles could be sailed over in a day with no expenditure of force save for the evolutions necessary to maintain the equilibrium, although this can only be done under peculiar circumstances, and the commercial use must be very much less than that of bicycles.

That this expectation is not altogether absurd will appear from a brief consideration of the power of the wind ; and to make the matter plain we will suppose it to have an upward trend of 15° or 26 per cent. or a very moderate inclination, which must be frequently exceeded. Under that circumstance a horizontal aeroplane will, as previously explained, have the horizontal component of the normal pressure directed to the front and acting as a forward propelling force. We may now calculate what the effect of this would be upon Herr *Lilienthal's* aeroplane.

This was proportioned in the ratio of 0.75 sq. ft. of surface to the pound of weight ; but as the surfaces were concavo-convex, we may assume that the coefficient of efficiency would be about the same as that which we have assumed heretofore for the pigeon, or 1.8 per cent. of the actual surface, and we may further simplify the calculations by assuming the equivalent *plane* surface as equal to 1 sq. ft. per pound to be sustained. Now if this be exposed to a wind blowing at the rate of 25 miles per hour, at which the rectangular pressure, as given by Smeaton's table, is 3.125 lbs. per square foot, and if we suppose the plane to be inclined forward, so as to point 5° below the horizon, then the wind will make an angle of 10° with the plane, at which the normal pressure, by our tables, will be 0.337 of the rectangular pressure. As the effect upon the plane is in the ratio of the angle which the latter makes with the direction in which we desire to calculate it—*i.e.*, the horizon, and this angle is 5°, the *sine* of which is 0.087, then we have for the propelling force for each square foot of sustaining surface :

Drift $= 1. \times 3.125 \times 0.337 \times 0.087 = 0.0916$ lbs. per square foot.

But as the speed is 2,200 ft. per minute, we have for the power :

Power $= 0.0916 \times 2200 \div 33000 = 0.00611$ horse power per square foot,

which for an apparatus with 172 sq. ft. of sustaining surface furnishes a motive power of

$$0.00611 \times 172 = 1.05 \text{ horse power},$$

which is the power at the disposal of Herr *Lilienthal* when the wind blows 25 miles per hour, with an upward trend of 15°.

This, of course, varies with the trend and the strength of the wind ; but it will be noticed that with the data assumed it will amount to some 6 horse power for an aeroplane with 1,000 sq. ft. of sustaining surface—an amount which will probably be surprisingly great to those who have not considered the subject.

It will doubtless be objected that these calculations are all based upon the assumption that the wind has an ascending trend, and that this condition does not uniformly obtain, particularly at sailing heights above the earth, where the wind may be horizontal at the very time that experiment shows an ascending trend near the surface. This is granted ; it is acknowledged that the calculations of power to be obtained from the wind are predicated upon an assumption which may be untrue part of the time ; but the answer to the main objection is that *the birds soar at all times* when there is wind enough (not too much), and that while we cannot yet explain how they do it, man ought to be able to avail himself of the same circumstances as the birds, if only he can maintain his equipoise.

This is what Herr *Lilienthal* has undertaken ; he has done so with great prudence and good sense, and so far as the results of his experiments have been published they teach several valuable lessons, which may be summed up as follows :

1. The upright position for the body of the aviator is the most favorable, as being most natural to man.

2. Safety while learning the management of an apparatus is promoted by beginning with comparatively small surfaces, because wind gusts are liable to destroy the balance. It is best to glide downward in initial experiments until practice has conferred the skill requisite to maintain the equipoise, in case the apparatus is tossed up in the air by the wind. This is a lesson which was not obvious, and it should be heeded by experimenters, some of whom have assumed that safety was best promoted by large surfaces.

3. The aviator must be so affixed to his apparatus that he can detach himself instantly should the machine take a sheer.

4. It is not safe to experiment in winds blowing more than 23 miles per hour until skill has been acquired in the management of the apparatus, or until the latter has been so improved as to minimize the danger.

5. It seems now reasonably possible for designers of soaring machines (and the writer knows several) to experiment with their apparatus without further search for some hidden secret, for Herr *Lilienthal* says that his experiments have taught him that there is no mystery about sailing flight; that the wind is sufficient to account for it. Inventors need not look for some new mysterious force, some "negative gravity,"* like that in Mr. Stockton's tale, to take them up into the air; nor need they be afraid that if they propose to experiment with soaring machines they will be considered lunatics. The main question for them to consider is that of the equilibrium.

Of course, even if this be worked out, the practical usefulness of a soaring machine would be very limited. It could only be availed of when the wind blew with about the favorable velocity (neither too slow nor too fast), and its field of daily use would probably be limited to the trade wind latitudes, or, in other words, to those regions inhabited by the sailing birds; but if the equipoise be worked out, if man succeeds in devising an adequate soaring apparatus and in learning how to use it, unhampered by the necessity for looking after a motor at the same time, it will not probably be long before some motor is added to confer upon him command of space at all times.

In June, 1891, the quidnuncs in Paris were interested in the rumored success of some experiments with a flying machine carried on near Paris, in the private park of Mr. E. Pereire, the banker, by M. *Clement Ader*, who was said to have succeeded in rising to a height of about 60 ft., and in flying a distance variously estimated at 100 to 400 yds.

M. *Ader* is a well-known French electrician, the inventor of a telephone, and has long been interested in the flying-machine problem. In 1872 he constructed an artificial bird 26 ft. across and weighing some 53 lbs., with beating wings actuated by the muscular force of the operator's legs, aided by elastic auxiliary pectorals. In high winds, and restrained by ropes in order to guard against accidents, it would lift up a man, but it was found, as many times before, that man has not the requisite energy to sustain his weight in calm air. Subsequently the same apparatus, or a modification of it (for the accounts are not quite clear), was set up under a shed at Passy, and visited by M. *de la Landelle*,† who states that the operator was stretched horizontally (a bad position) between the wings, and worked with his feet and hands the organism of transmission to the parts that acted upon the air. A certain lifting effect was produced, but not enough to sustain the whole weight. This apparatus was never photographed, but its inventor now contemplates unboxing it and setting it up again as a curiosity.

In 1891, as already mentioned, M. *Ader* built another artificial bird 54 ft. across, with which he experimented in the open air with such close privacy as he could secure; but the details are being kept secret, as the inventor states that he believes that it is destined to play an important part in the national defence of his country. He merely mentions the fact that the motor and the man who works it are placed in the interior of the machine, which is shaped like a huge bat; that the motor is actuated by a "mixture of a combination of vapors," and that the instrument of propulsion is a screw (of which he tried some eight patterns) placed at the head; that the whole apparatus rests upon skates or upon wheels, and that he needs a long, smooth, flat space to gather headway by sliding or rolling some 20 or 30 yds. or more. He stated that he had already expended some $120,000 in his aerial experiments during the 15 years that he had been working at the problem, and that he contemplated exhibiting his machine in the air, if he could secure the use of the great machinery hall built for the Paris Exposition of 1889.

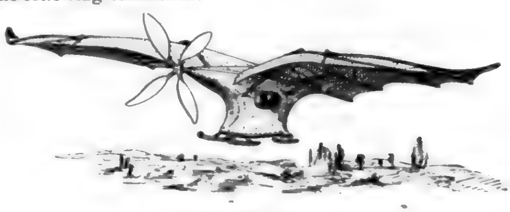
The above data are extracted from an account of an interview with M. *Ader*, published in the Paris *Temps* of July 9, 1891, in which he gave an interesting account of the preliminary studies that led to his last conception, the result, as he says, of a private theory of the resistances of air, which he proposes to publish some day.

Moved, probably, by the accounts of the sailing of large birds published by M. *Mouillard*, as witnessed by him in Africa, M. *Ader* first obtained from the zoölogical gardens some eagles and some large bats, and observed their flight in his workshop. Judging this to be insufficient, he next went to Algeria, but could find none of the large vultures near Constantine; so, disguising himself as an Arab, he went into the interior with two Arab guides, and by enticing the birds with pieces of meat left in secluded places, he succeeded in obtaining ample observations.

M. *Ader* states that he became fully convinced that these vultures, some of them measuring 10 ft. across, do not beat their wings when rising on the air; that they flap them at most two or three times when first rising from the ground, and then hold them rigidly spread out to the current of wind upon which they ride, and upon which they rise in great circling sweeps by merely adjusting their aeroplane to the varying conditions of incidence and force of wind.

Starting from his theory and observations, M. *Ader* next built the machine which he has been experimenting with near Paris, in the presence, it is said, of only three or four persons, and with many precautions to avoid divulging his secret. He has even announced that he intends, from patriotic motives, to take no patents in foreign countries, so as not to divulge the design of his apparatus, and that all he can say at present is that the problem is an exceedingly difficult one, involving enormous mechanical difficulties, which increase rapidly with the size of the apparatus.

Naturally this reticence excited curiosity, and the French paper *L'Illustration*, in its issue of June 20, 1891, published a picture from which fig. 75 is reproduced, and it also made the following comments:



ADER—1891.—Fig. 75.

Nobody has seen anything, nobody knows anything, but *L'Illustration* has its friends everywhere. One of them was hunting lately in the environs of Paris, when he caught a glimpse through the leaves of a strange object resembling an enormous bird of bluish hue. It was impossible to approach close to it; an enclosure surrounded the private park shut in by the forest in which the aforesaid machine was situated. Assuredly it could only be a flying machine. Our friend is something of a limner as well as an engineer, and he communicates to us the sketch which he made from a distance, and which is as correct as it was practicable to make it. Upon making due inquiry it turns out to be the invention of M. *Ader*,

* One theorist expounds his ideas as follows: "One point I have studied, and that is, How can a twenty pound wild goose carry itself so easily? Weigh every feather you can pick off from a wild goose and they will not weigh one pound. Now if the feathers be picked off from the goose he can come no nearer flying than we can.

"So there we have it clearly demonstrated that one pound of goose feathers can pick up nineteen pounds of goose and carry this nineteen pounds and its one pound of feathers through space at about half a mile a minute, if in a hurry.

"Now my theory is this, and it applies to all birds. Notice any bird when he suddenly starts to fly, and you will notice a lightning-like quiver of his feathers. I believe that this quiver causes the production of a negative force of magnetism, or some kind of force which pushes the bird from the earth—just the reverse of the loadstone. He then has only to use his wings to propel the body, for the magnetic negative earth-force does the lifting, and that is all produced by the feathers. If it were not, then the bird ought to fly when divested of his feathers. This is the force which should be looked for; whoever discovers it will make a fortune."

† Dans les airs, G. de la Landelle, pp. 236, 237.

the electrician, well known for his telephone apparatus, and it seems that the machine has really flown several hundred yards, rising some 50 to 65 ft., and holding a course through space. . . . .

The name of the inventor of this machine should be a guarantee of its possible success ; still we have our doubts. It is said to have glided a certain distance in the air—100 or 200, or, say, 400 yds. But can it continue to do so for several hours, without having recourse to some fixed supply of power to recharge the motor actuating it ? For this is the vital point : what is the motor ? As the inventor is an eminent electrician, thoroughly understanding this new science, he must have selected his favorite motor, the dynamo.

But electric accumulators are impracticable on account of their weight, while primary batteries act for only a short time, and they, too, are heavy.

Therefore, for the present, and until we have witnessed a convincing experiment, at which we shall have seen with our own eyes the generator of the power employed, we shall remain skeptics, and we shall believe (and this only because of the high scientific standing of the inventor) that if the machine sketched by our friend can really fly, it is only for a very brief period of time.

In point of fact, it is surmised by the writer of these lines that M. *Ader* has really been experimenting with a soaring machine, using a motor only to get under way, and, if the sketch of the apparatus is correct, that the principal difficulty he has met with has been to maintain the equilibrium. He may have had a few good flights under favorable circumstances, but he must have had many mishaps.

It is probable that one of his errors lies in adopting too large a sustaining surface, under the mistaken belief that this would promote safety. It would probably do just the reverse, by enabling little wind gusts and ground currents to upset the equipoise. The machine is 54 ft. across, and must spread to the breeze twice the surface employed by Herr *Lilienthal*, which we have already seen is found by the latter to be dangerous in winds of more than 23 miles per hour.

In August, 1891, M. *Trouvé*, whose mechanical bird with flapping wings actuated by explosions within a Bourdon tube, and whose hovering screw machine, worked by a dynamo connected by a wire to a source of electrical energy remaining on the ground, have already been noticed, deposited with the French Academy of Sciences a sealed letter, containing descriptions and drawings of an aeroplane, which he believes to be destined to solve successfully the problem of aerial navigation.

This method of depositing sealed descriptions of inchoate inventions with the Academy of Sciences is a favorite one in France, and answers generally much as the filing of a caveat does in the United States.

Nothing is known, of course, concerning the designs for this aeroplane, but M. *Trouvé* says that he has made great strides toward developing his aerial apparatus since 1870, and especially since 1884 ; that his laboratory experiments have convinced him that while his explosion motor is satisfactory as to the power exerted in proportion to weight, wings are less efficient than screws as instruments of propulsion. He has therefore designed an aeroplane propelled by two screws, rotating in contrary directions, which he believes to be superior to the former arrangement of beating wings.

The arrangement of this aeroplane is said to be such that the surface may always be proportioned to the weight to be carried, no matter what that weight may be.

The method of obtaining initial velocity is ingenious and effective. The apparatus is to be placed upon a railway car, and this is to be towed by a locomotive upon an ordinary railway, until the speed is sufficient to furnish the required reactive support from the air ; when the machine rises, and is thenceforth supported by its sustaining surfaces, driven by the two screws moved by the explosion motor.

M. *Trouvé* believes that success is now a simple question of money expenditure, and that the daring man, favored by fortune, who first navigates the air, will reap the glory of that success with less title thereto than his predecessors, who have pointed out the way.

In 1891 *Gustav Koch*, an aeronaut of Munich, published a pamphlet entitled "Free Human Flying, as the Preliminary Condition of Dynamic Aeronautics," * which contains the plan and description of an apparatus designed by him, with which he proposes to imitate the soaring of the birds, and which also gives an account of the experiments which he had tried with models. This design has been thought worthy of trial, and the Bavarian Ministers of the Interior and of Education in May, 1893, granted 1,600 marks ($400) to Herr *Koch* to enable him to make experiments. This he is about to do (with an assistant) over the lake of Constance near Lindau, and while the results may not prove satisfactory, they cannot but prove interesting.

The aeroplane designed by Herr *Koch* consists in a pair of rigid wings, approximately shaped like those of the dragon fly, each about 27 ft. long and 6 ft. broad, back of which there is a triangular tail, some 7 ft. long and about 8 ft. wide at the rear end. The wings are to be constructed of bamboo, covered with unbleached silk slightly oiled, and pivoted to the back of the operator. The latter is to lie horizontally, face downward, in a sort of hammock suspended from a frame which attaches to the wings, and the latter can thus be swung forward or back within small limits, so as to change their position with respect to the center of gravity, but they have no flapping action whatever. The operator is to swing the wings and to elevate or depress the tail by means of pedals on which his feet rest, and of lines leading to his hands.

It will thus be seen that the action of the apparatus, which is some 57 ft. across, consists in altering the position of the center of pressure, with respect to the center of gravity, by swinging the wings forward or back, and thus changing the angle of incidence which the apparatus makes with the course, while still further changes can be produced by the action of the tail.

The weight of the aeroplane, including the mechanism which works it, is estimated at 99 lbs., and that of the operator at 176 lbs., making a total of 275 lbs., to be sustained by about 325 sq. ft. of surface.

Herr *Koch* proposes to test the apparatus by taking it up beneath a balloon and cutting it loose when about 3,000 ft. in the air. The first experiments, of course, are to be tried with a dummy instead of a man, and if these indicate sufficient strength and stability, the operator is to take the place of the dummy. He expects the machine to descend like a stone for the first second or two, and then, when air pressure has gathered under the wings, to gradually right itself, and to glide downward upon an easy slope, which would bring it down to the water in about 8 minutes and a distance of some 2½ miles, thus being a dirigible parachute. Meanwhile, however, the operator is expected to bring the apparatus under control ; by swinging the wings forward he expects to tilt the planes so as to glide upward again, by virtue of the acquired momentum, and by movements of the tail and of his own body, which has a certain latitude of motion in the hammock, he expects to tack and to sail upon the wind like a soaring bird, sweeping in circles or making a series of zigzag glances, during which elevation might be gained by utilizing the force of the wind.

Such is the scheme ; it is not wholly devoid of merit, because the soaring birds perform those very manœuvres, and they do it much in the way which Herr *Koch* has indicated, but it may be questioned whether his apparatus is properly designed to accomplish the results desired. In the first place, the sustaining surface and the spread across are too great, and will terribly strain the strength of materials. It would be better to shorten the wings and to make them broader in order to reduce the length of leverage. In the second place, the horizontal position selected for the operator, probably to reduce horizontal resistance, is decidedly bad, because it is unnatural to man, and gives him inadequate control over the apparatus. The man should be placed vertically, and instead of manœuvring, as planned, to cause the back part of the tail to strike the ground first and roll along, while the aeroplane settles forward slowly, the operator should alight on his feet and stop his impetus while running if he alights on land. In the third place, the mode of experimenting proposed is exceedingly dangerous. Herr *Koch* says, quite properly, that the first step toward

* Der freie Menschliche Flug, als Vorbedingung dynamischer Luftschiffahrt. München, 1891.

success in artificial flight consists in acquiring the skill in managing an apparatus, but until that skill has been acquired it will evidently be little short of suicide to cut himself loose high in air, even if over a bed of water.

Perhaps, however, these various elements of failure have already been eliminated. The design was published in 1891, and may by this time have been so remodelled as to lead, not to an absolute success, for this is not to be expected, but to such partial control over the apparatus as to warrant further experiments.

In the *Cosmopolitan Magazine* for November, 1892, and in *Cassier's Magazine* for February, 1893, appeared two analytic articles by M. *J. P. Holland*, in which he takes the ground that mechanical flight has already been proved to be attainable, that what remains to be done is merely to combine things already tried and proved by other experimenters; and in which articles he advances three proposals or designs for flying machines.

In the *Cosmopolitan* article M. *Holland* proposes to place two aerial screws, superposed and rotating in contrary directions, above a spindle-shaped body containing the machinery, with a pair of wings or aeroplanes attached. This may be termed his first design, as indicated by his figs. 2, 3 and 4. In his second design the spindle and the superposed screws are retained, but the supporting surface consists of 10 narrow, superposed, concavo-convex aeroplanes, somewhat like a Venetian blind, and they as well as the screws are mounted upon a frame pivoted to the spindle-shaped body, so that the screws may first be used to raise the apparatus from the ground, and then to drive it forward when the frame is raised to the vertical, support being then derived from the aeroplanes. This is indicated in M. *Holland's* figs. 5, 6 and 7.

In the *Cassier's Magazine* article the design is further modified by placing the aerial screws side by side in the frame instead of superposing them. The superposed aeroplanes are retained, but the number is increased to 16, and the mode of operation is much the same.

The design is somewhat similar to that which Mr. *Phillips* experimented in England, which was illustrated in *Engineering* of May 5, 1893, but is an improvement upon the latter design in the provision for pivoting the Venetian-blind aeroplanes to the body, and in the employment of two screws instead of one for the propelling instrument.

(TO BE CONTINUED.)

CURVE DEVICE FOR CABLE RAILWAYS.

The difficulties which have heretofore been experienced in this matter are that when a curve is reached it becomes necessary to practically carry both cables of the double system on one side of the slot, and it must necessarily occur that one cable is above the other. Therefore, when the grip is adjusted for one, it will evidently be too high or too low for the other, and the result is that the cable which is below the other one in its normal position must be wound down by a worm, or else forced down in some other way, so as to avoid dragging over the upper cable. When the upper cable is in use it can usually be delivered directly against the carrying wheels without any difficulty.

The device which we illustrate is one recently brought out by the Rapid Transit Cable Co., of No. 12 Broadway, New York, and intended to overcome the difficulty of delivering the lower cable directly into the carrying wheel that is intended for it. It will be seen by reference to the end elevation of our engraving that there are two carrying wheels, one above the other, when the cables are in position. The upper wheel, marked *A*, runs in rigid bearings and does not vary from its position, as shown by the engraving. The cable, on being freed from the grip or after the car has passed, is at such a height that the strain of the curve naturally draws it back into the position shown in the engraving; but it will be seen at once that the cable for the lower pulley *B*, when the car has passed, is too high to drop into that pulley when it is in the position shown, and therefore would naturally drag over the upper cable; but the pulley *B* is pivoted to the point *C*, which is between the center and the rim of the pulley, so that the pulley is practically overhung, and its natural position when free from the cable is that shown in the bottom engraving, which is placed in the foundation, fig. 2. The pulley assumes this position as soon as it is freed from the strain of the cable, because its gravity tends to swing it into that place about the point *C*. Therefore, as soon as the car approaches and the strain of the cable is taken off the pulley *B* it swings into the position of fig. 2; and as the car passes and the cable comes back into the normal position of the curve, directly over the upper cable, it naturally drops into the groove of the pulley *B*, and causes a strain to be put upon the latter, swinging it back into the normal position of the upper portion of the engraving, and carrying the cable down with it. There is no mechanism to get out of order, the pulley is clear from the grip at all times, and when there is any strain at all upon the cable, it naturally would draw this pulley down, as it requires but very little in order to do so. On the other hand, the moment the strain of the cable is removed from the pulley

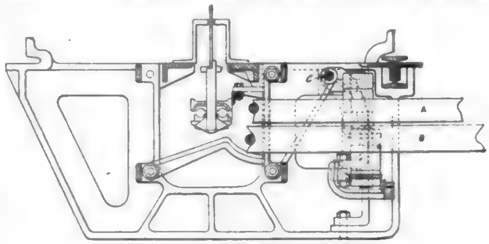


Fig. 1.

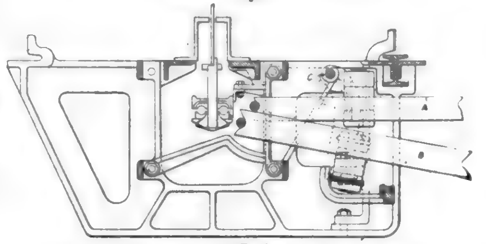


Fig. 2

CROSS-SECTIONS OF CURVE PULLEYS FOR CABLE RAILWAY.

gravity swings it into the proper position for catching it when the car has passed. It is one of those simple little devices that seems strange not to have been thought of before.

LAUNCHES FOR CHINA.

The State Department has just received from United States Consul Fowler, at Ningpo, the following communication which ought to be of great interest to manufacturers of steam, oil, or electric launches.

"In a recent interview with the Taotai of this circuit, I pointed out to him the great advantage in the saving of time and comfort that would accrue if he adopted the modern method of traveling by the use of steam, oil, or electric launch in his journeys about this district. I explained, to the best of my ability, the workings of the various kinds of launches, and he seemed so pleased with the idea of being able to travel with greater comfort and more speed than is now the case, that he requested me to write to the United States for particulars; therefore, I have the honor to request that the Department will kindly place this before the manufacturers of launches, in order that they may tender diagrams, cuts, etc., so that I can have the matter placed before his Excellency, thus enabling him to select such launch or engine as seems most suitable for these waters. It must be remembered that this vast district is intersected by thousands of miles of canals and rivers; and, although it covers a territory of 39,500 square miles, and has a population of from 25,000,000 to 35,000,000 people, there is not a single launch or boat of any kind propelled by steam, oil, or electricity, excepting a few launches that ply from Shanghai to Hanchow, the capital, 150 miles northeast of this port.

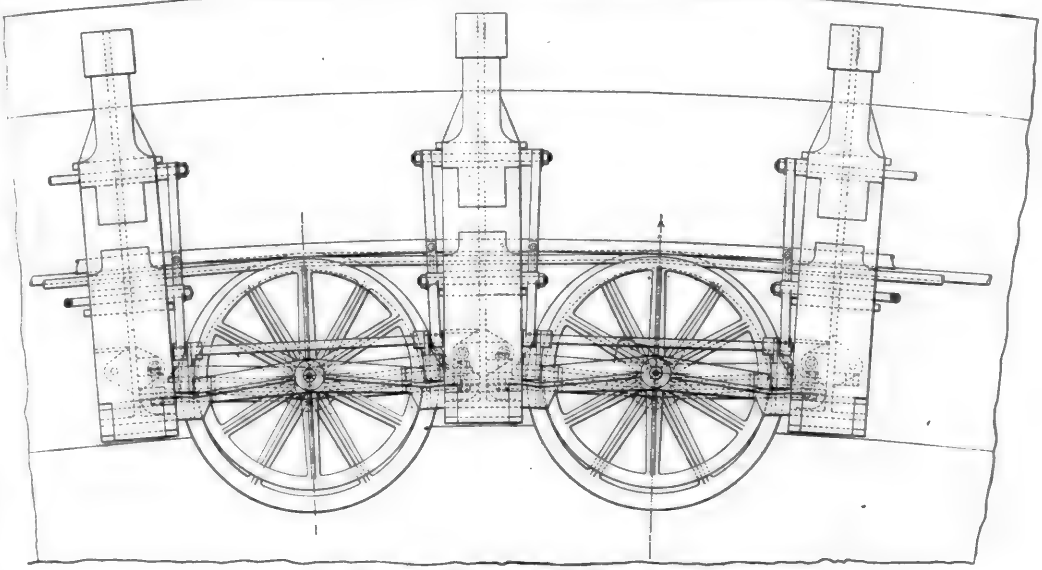
"The Taotai has occasion to go to the capital frequently. He travels in a small covered boat propelled by *ya lows* (large oars), worked similarly as a whaleboat is worked—*i.e.*, by sculling. The average distance traveled in a day is 100 lis, or 33⅓ miles.

"A boat suitable for China would have to be built very strong, the propeller be so arranged that it could be taken up or protected in some way from the ropes that are passed around the stern of the boat while it is being pulled over the 'haul over' from a river to a canal, or from a lower to a higher

canal. A 'haul over' (over part of this bank sloped for the purpose by masonry or earthwork and covered with wet and slippery clay) forms a sluiceway. A boat to pass from a river to a canal has a rope passed around the stern, the ends of the rope being wound around a windlass on each side of the sluice. Men work the windlass on both sides until the boat has been hauled to the ridge, when it is pushed into the water. There are no locks. Sometimes a boat is dragged across a 'haul over' by water buffaloes or oxen, but the first method is the common one hereabouts.

"Another consideration is, that in some places the canals are only wide enough for a boat of the regulation size. This is especially so between the supports or arches of bridges. Finally, the bridges are so low that it is of the greatest importance that the roof of the cabin or cover should not be so high as to prevent the boat from passing under them.

"The boats for traveling are called house-boats. Foreign boats use a hull built native fashion, and in or on this hull is erected a small house, fitted with windows, berths, closets, etc. They are quite comfortable, and one can travel for weeks; in fact, it is the only way one can travel in this part of China. The boats used by the natives are not so comfortable, yet are often more expensive.



PLAN OF CURVE PULLEYS FOR CABLE RAILWAY.

"If it is possible for manufacturers to build an engine that can be placed in the boats used here, I think that there would soon be a large demand for such engines. The canals are the only roads, and all travel is, of course, by boat. The traffic carried on by boats is very large. The introduction of quicker methods of travel would be highly appreciated, especially if the Taotai sets the example, and I deem this a most auspicious time to introduce our methods into this province.

"Some years ago I saw in Washington a boat which I think would be especially well adapted for China. If I recollect aright, it was a petroleum launch made in Providence, R. I., by Brayton; but such rapid strides have been made since then that possibly there may be more suitable kinds on the market now.

"For the guidance of interested parties the following description may be of some use: Length, 33 ft.; breadth, 6 ft. 10 in.; height, from keel to rail, 2 ft.; height, from rail to top of house, 2 ft. 9 in.

"A flat-bottom boat is of course preferable, and one that follows the Chinese style. It has occurred to me that it may be possible that a boat could be built with a top or house, having the sides arranged in such a manner that it could be telescoped or lowered; in that case the roof could be higher than in a stationary one. One without a smokestack or with a smokestack that is easily lowered would be popular; in any case the stack must be a very short or low one. It would be well for the manufacturers to include in their estimates the cost of delivering the same by steamer or sailing-vessel at Shanghai or Hon Kong.

"I have been discussing the benefits of small launches with the Taotai for the past two years, and now he has requested me to find out all I can for him. If he should adopt a launch for his own use, I am quite confident that it will not be long before many orders will be placed with our manufacturers. There is a splendid opening here. An immense traffic is carried on in boats, which now depends on the tide and the endurance of the *yu loese* (scullers). A company has been organized at Swatow of Chinese, who run a steam ferry (launches) a short distance upriver, and I understand they are doing a very lucrative business."

INFLUENCE OF TEMPERATURE ON THE MECHANICAL PROPERTIES OF BRASS ON ANNEALING.

We know that the mechanical properties of hammered brass are very considerably modified by annealing. An examination of the variation of these properties, due to the action of annealing temperatures, has been made with the view of determining whether this phenomena can be attributed to a variation in the structure of the alloy. The researches have up to the present time been limited to brass composed of 67 per cent. copper and 33 per cent. zinc, used in the manufacture of embossed work, and which possesses remarkable malleability. A sheet .315 in. thick has been hammered down until it was only .08 in. in thickness, and that, too, without annealing. From the brass that has thus been hammered down a series of bars have been cut for the purpose of making tensile tests the breaking strain and elongation of which have been determined after having been annealed at various temperatures.

The annealing was accomplished by means of a furnace heated by platinum spiral, which was traversed by an electric current, thus permitting constant temperatures to be obtained. The temperatures were measured by Le Chatelier's thermo-electric pyrometer. The following are the results obtained:

° Fahr.	Breaking strain lbs. per sq. in.	Elongation.
	88,171.5	3.8%
1,004°	45,511.2	55%
1,085°	45,079.05	57.3%
1,148°	42,666.75	60 8%
1,292°	41,667	64.8%
1,346°	42,666.75	62%
1,580°	39,248.25	59%
1,706°	37,677.35	56.5%

LOCOMOTIVE RETURNS FOR THE MONTH OF APRIL, 1893.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage.					Av. Train.		Coal Burned per Mile.						Cost per Locomotive Mile.							Cost per Car Mile.		Cost of Coal per Ton.
			Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Passenger Cars.	Freight Cars.	Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Passenger.	Freight.	
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Alabama, Great Southern	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Alabama & Vicksburg	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Atchison, Topeka & Santa Fé	834	716	...	...	470,677	2,084,349	3,520	...	...	...	...	...	81.42	...	...	3.69	6.80	0.28	1.67	6.43	0.14	19.01	...	...	1.59
Canadian Pacific	612	...	479,005	722,823	340,803	1,542,631	2,520	...	...	...	...	...	84.96	...	...	4.28	11.70	0.37	...	5.71	1.48	23.54	...	...	3.26
Chic., Burlington & Quincy	543	...	...	...	...	1,700,181	3,131	4.97	18.13	...	...	...	88.65	...	...	6.15	6.10	0.25	0.21	7.33	0.07	20.11	...	...	1.38
Chic., Milwaukee & St. Paul	825	...	...	...	...	2,642,991	3,191	...	...	...	...	...	74.85	...	...	4.16	7.68	0.28	...	6.88	...	19.00	...	...	2.00
Chic., Rock Island & Pacific	564	...	541,904	910,937	423,107	1,875,948	3,324	...	...	...	...	...	68.19	...	...	3.11	6.35	0.27	...	5.87	0.42	16.02	...	...	2.00
Chicago & Northwestern	868	...	683,482	1,311,108	264,792	2,619,382	2,939	...	...	...	...	...	90.49	...	...	4.31	8.05	0.35	...	6.30	0.90	19.96	...	...	1.75
Cincinnati Southern	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cumberland & Penn.*	...	22	5,317	34,430	...	39,747	1,806	...	...	...	...	...	83.33	...	...	6.20	4.79	0.15	...	...	1.87	13.01	...	...	...
Delaware, Lackawanna & W. Main L.	...	189	...	...	...	607,402	3,213	...	...	...	...	...	97.70	...	...	3.53	7.46	0.47	...	6.29	...	17.55	...	...	...
Morris & Essex Division	159	..	159,604	149,078	88,788	397,470	2,499	...	...	...	...	...	70.25	...	...	4.15	10.93	0.45	...	6.81	...	22.33	...	...	3.07
Hannibal & St. Joseph	73	...	...	...	...	260,765	3,779	5.27	16.33	...	...	...	80.74	14.56	6.55	3.34	6.01	0.14	0.36	6.56	0.08	16.44	...	...	1.41
Kansas City, F. S. & Memphis	144	...	98,253	328,774	12,720	438,772	3,083	...	...	...	...	...	63.96	...	...	3.91	5.46	0.26	0.41	7.52	...	17.56	...	...	1.67
Kan. City, Mem. & Birm	42	37	34,955	49,747	14,480	99,181	2,679	...	...	...	...	...	68.09	...	...	4.12	3.58	0.24	0.35	7.31	...	15.60	...	...	1.01
Kan. City, St. Jo. & Council Bluffs	88	35	...	...	...	135,096	3,651	5.03	20.47	...	...	...	65.08	12.91	4.76	3.17	5.99	0.15	0.23	5.98	0.08	15.55	...	...	1.99
Lake Shore & Mich. Southern	594	...	427,705	849,486	569,962	1,847,213	3,109	...	...	63.19	92.68	35.91	68.43	...	...	3.03	5.42	0.07	...	6.93	0.18	15.75	...	...	1.57
Louisville & Nashville	...	348	412,729	755,283	400,814	1,568,525	4,507	5.13	6.13	63.78	113.20	49.21	83.02	14.09	6.85	4.64	6.65	0.27	1.46	6.07	0.68	19.74	3.43	1.50	1.82
Manhattan Elevated	...	293	765,132	...	58,920	824,052	2,813	...	...	...	...	...	45.76	...	...	2.60	9.00	0.20	...	8.90	...	20.70	...	...	3.94
Mexican Central	148	115	73,964	...	...	387,655	2,370	...	...	...	...	...	69.90	...	...	5.27	13.94	0.52	0.21	5.26	0.85	26.05	...	...	4.46
Mil., L. S. & Western	112	...	...	193,029	66,549	269,583	2,406	...	...	...	...	...	77.30	...	...	3.43	10.76	0.22	...	6.22	1.01	21.64	...	...	2.80
Minn., St. Paul & Sault Ste. Marie	...	...	61,228	153,040	46,273	260,541	...	5.19	16.76	...	...	...	82.43	...	...	5.10	14.22	0.27	...	6.80	...	26.39	...	2.34	3.44
Missouri Pacific	338	...	...	...	...	1,080,961	3,483	4.33	15.96	...	...	...	84.81	...	...	5.45	6.07	0.33	1.24	6.56	1.39	21.24	4.25	1.57	1.40
Mobile & Ohio	107	84	67,281	142,033	44,106	253,422	3,136	...	...	...	...	...	61.50	...	...	3.21	4.39	0.32	0.67	5.72	1.02	15.23	...	...	1.43
N. O. and Northwestern	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
N. Y., Lake Erie & Western	607	410	443,741	868,813	275,894	1,588,448	3,874	4.60	22.20	91.60	135.20	77.90	...	19.90	6.10	5.28	8.07	0.39	2.43	7.28	1.17	24.62	...	...	1.45
N. Y., Pennsylvania & Ohio	200	172	137,300	448,728	150,780	736,808	4,283	5.70	17.80	78.00	131.40	91.55	...	13.70	7.40	3.34	6.22	0.30	1.86	6.80	0.98	19.50	...	...	1.12
Norfolk & Western, Gen. East. Div.†	...	...	113,201	310,885	54,869	478,955	2,817	5.00	20.90	50.81	121.10	...	...	10.01	5.60	5.50	3.90	0.70	...	...	...	10.10	...	...	...
General Western Division†	...	...	103,115	303,496	46,493	453,104	2,665	5.70	17.00	76.00	128.00	...	114.00	13.41	7.54	5.42	4.40	0.54	...	...	...	10.36	...	...	...
Ohio and Mississippi	112	...	138,740	137,916	91,799	368,455	3,288	...	...	...	...	...	82.38	...	...	3.20	3.54	0.25	1.78	5.41	1.53	15.31	...	...	0.86
Old Colony	...	238	328,494	130,786	145,305	604,585	2,540	...	...	...	...	...	61.53	...	...	3.36	11.54	0.62	...	6.71	0.81	23.04	...	...	3.75
Philadelphia & Reading	...	...	440,840	314,632	889,802	1,645,274	...	...	...	...	...	...	81.67	...	...	4.53	4.65	0.35	...	5.76	0.42	15.71	...	...	...
Southern Pacific, Pacific System	..	718	...	...	...	...	...	...	...	...	...	...	70.12	...	...	6.43	18.24	0.22	2.18	7.27	1.20	35.54	...	...	5.28
Union Pacific	992	...	695,333	1,206,844	355,457	2,357,634	3,492	5.76	16.77	81.10	135.68	...	97.60	14.06	8.10	6.27	9.91	0.40	0.87	8.09	1.22	26.76	4.21	2.04	2.01
Vicksburg, S. & P.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Wabash	425	352	395,114	607,238	294,876	1,297,228	3,685	5.07	16.98	69.73	110.92	57.48	86.24	13.72	6.53	3.40	4.86	0.29	...	6.29	0.98	15.77	2.70	1.08	1.15
Wisconsin Central	153	121	121,215	233,451	66,399	421,065	3,479	...	...	...	...	...	94.96	...	...	2.78	9.36	0.27	...	7.23	...	19.64	...	...	1.99

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

We see that the breaking strain decreases regularly with the rise of the annealing temperature, while the elongation begins by increasing, reaches its maximum at about 1,292° Fahr., and then decreases down to the melting point. From each bar, before the tensile test was applied, a small plate was cut out, which was examined by the micrographic method. In order to obtain constant results in this kind of research, it is absolutely necessary that some fixed method of preparation of the surfaces to be examined by the microscope should be decided upon. The polished surface is easily attacked by the electric current. This is the process which was employed by Guillemin for the examination of the copper alloys. But according as the intensity of the current, the electro-motor force, the composition of the liquid and the duration of trial varied, entirely different results would be obtained with the same metal.

An examination of a great number of preparations submitted to different methods of attack led to the conclusion that brass is generally formed of two different alloys. In attacking polished surfaces it is therefore necessary to use an electro-motive force whereby one of the alloys would be dissolved while the other would remain unchanged. This can be done by the following method: The alloy to be examined is placed in a solution of sulphate of zinc and is connected with a plate of copper, which is placed in a porous jar filled with the solution of the sulphate of zinc. The sulphate of zinc may be replaced by diluted sulphuric acid, if it is desired to limit the duration of the attack. Under these conditions, and by using equal surfaces and solutions of the same concentration with identically the same duration of attack, results may be obtained which are comparable to the different standards of variations in the structure of the metal due to annealing. In carrying on these operations the following facts have been observed:

Brass which has been subjected to heavy hammering is practically a homogeneous structure; the attack only causes lines which appear in the direction of the laminations. As the brass is annealed it tends to separate into crystals which are of octahedral form which become clearer. As the temperature rises above the temperature of 1,292° Fahr. these crystals begin to become distorted; blow-holes will appear which are probably due to the volatilization of the zinc, and their numbers increase with the rise of temperature. Finally, at a temperature just above 1,832° the metal fuses, and on cooling crystallizes into the form of dendrites, which are probably formed by the isomorphus mixture of the metal.

The co-relation which exists between the mechanical properties of the brass and that separation of the two alloys, the one crystalline and the other amorphous, playing the *rôle* of cement, constitute an embryo of a theory similar to the cellular theory of steel of Messrs. Osmond & Werth, and may give some indications which will be useful in working the metal. The facts which have thus far been observed have already led to a variation from the generally accepted ideas that, in the case of brass, crystallization improves the mechanical qualities of the metal.—*Moniteur Industriel.*

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

The object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in June, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN JUNE.

Marshalltown, Iowa, June 1.—A special freight collided with a regular freight on the Chicago & Northwestern just west of Montour on a curve this evening. The trainmen all jumped and escaped injury, except one of the engineers, who was severely but not fatally injured. The accident was caused by the special not receiving orders to wait for No. 2 at Montour.

Susquehanna, Pa., June 1.—Peter Wentz, a fireman on the Buffalo Division of the Delaware, Lackawanna & Western Railroad, running between this place and Elmira, was standing on the steps of the tank looking at something about the engine when he was struck by the mail catcher the other side of Conklin knocking in three ribs and otherwise injuring him. He was brought home, where he is doing as well as can be expected.

Paterson, N. J, June 2.—An accident occurred this afternoon to a fast freight train on the Erie Railway at Nobody's, near Narrowsburg, by which the tender of the engine and 20 cars went down a 70-ft. embankment and were wrecked, several other cars remaining on the bank. Fireman Bad, of Port Jervis, was slightly injured by jumping from the engine. The breaking of a journal beneath the tender caused the accident.

Binghamton, N. Y., June 2.—Lewis Schanz, the fireman of the pusher engine which was involved in the Delaware & Hudson wreck at the tunnel to-day, was quite severely bruised when he jumped from the engine. One arm and shoulder was wrenched, his head was hurt and one hand scalded.

Cortland, N. Y., June 5.—A through express to New York on the Delaware, Lackawanna & Western Railroad, due here at 11.20 to-night, collided with a run away engine on the iron bridge three quarters of a mile north of this station. The engine had been in the yard here and was in charge of the night-watchman, who says he was in the engine house when the engine suddenly started off. He tried to catch it, but was unsuccessful. The engine went out on the south-bound track until it came to the iron bridge, where it collided with the express train, which was running at the rate of 30 miles an hour. The engine of the express bounded into the air and tore off the top of the bridge and then fell back on top of the run-away engine. Two day coaches, a smoker, sleeper, baggage cars and express engine then went completely over the run-away engine. The express engine separated from the train, ran about 100 ft. and turned completely over into the ditch. Engineer Isaac Wallace was killed instantly. The fireman, Bert Sherwood, was taken from the wreck in a badly bruised condition, and died at Cortland hospital a few hours after being taken there. The watchman has been arraigned, charged with manslaughter in the second degree.

Le Roy, N. Y., June 7.—An Erie engineer named Master fell from his engine in an unknown manner, east of Arron a few days ago, and was badly injured.

New Haven, Conn., June 7.—The Washington express on the Shore Line was wrecked at East Lynne, about half-past eleven to-night, by colliding with a freight train running in an opposite direction in the same block. Both engines were demolished, and the express and baggage cars of the Washington express were thrown from the track. The firemen and engineers of both trains were severely shaken up, but not seriously hurt.

Philadelphia, Pa., June 7.—James Norman, fireman of a work-train locomotive on the new Reading branch to Frankfort, was decapitated by the engine on which he worked today. The accident occurred on the deep cut where the road crosses the old Second Street turnpike. Norman had stepped out on the front of the engine while in motion to do some oiling, and lost his balance and slipped over so that the wheels passed over his neck and severed his head from his body.

Jamestown, N. Y., June 8.—Erie train No. 3 was wrecked just as it was coming into the city at noon to-day. Fireman D. J. Smith, of Greenville, Pa., was badly scalded, but no one else was injured beyond a little shaking up. Four cars and the engine were derailed. These were the baggage and mail cars; the smoker was thrown off the tracks. The baggage cars were badly wrecked. A stone wedged between the plank and a rail of a street crossing caused the engine to jump the track.

McKeesport, Pa., June 8.—Fireman Ed. P. Winton fell from an engine of a coal train at noon to-day while at Belle Vernon and broke his ankle.

Port Clinton, Pa., June 9.—Engineer Alfred Runkle, of the Philadelphia & Reading Railroad, was looking out the cab window this morning when his head was crushed by the bridge. He died instantly.

Youngstown, O., June 9.—W. J. Cooper, fireman of Pittsburg & Lake Erie Road, broke his leg about eight o'clock this evening by falling from his engine. He was engaged lighting the head-light, and in some manner lost his footing and fell to the ground, breaking his leg near the ankle.

Croton Falls, N. Y., June 9.—An attempt was made this morning to wreck a Chatham local express bound from New York when the train was midway between Croton Falls and Purdy Station. It suddenly ran into an obstruction on the track. It was going at so slow a speed that no damage was done. The engineer was thrown forward, but not injured. The accident was caused by a pile of fish-plates on top of the

track, placed there by a man, who, when arrested, confessed the crime, but gave no definite reason why he committed it.

Chicago, Ill., June 10.—A locomotive engineer named J. B. Onions, on the Chicago & West Indiana Road, was knocked off the front of his engine this morning by a passing Wabash engine and badly injured. The wheels of the Wabash engine passed over his leg, cutting it off beneath the knee.

Hagerstown, Md., June 12.—Thomas Horn, a freight fireman on the Cumberland Valley Railroad, received some ugly wounds to-ni ht. He was filling the tank of his engine with water from the standpipe at Shippensburg, when the heavy metal spout became loose by the chain breaking, and falling, struck him on the head and shoulders, knocking him prostrate on the tender. His wounds consisted of a long gash across his head, a cut ear and a bruised shoulder.

Little Rock, Ark., June 13.—A passenger train from Fort Smith and a north-bound stock train collided this morning near Butter, I. T. Engines, baggage and mail cars were telescoped and the stock car ditched. Amos Frame, engineer of the stock train, and his fireman were killed. The other fireman, named Stevenson, is missing, and Engineer James Gates, of the passenger train, is fatally injured. More than a score of persons were injured, some of whom may die.

Cedar Rapids, Iowa, June 14.—Limited train No. 2 on the Chicago, Milwaukee & St. Paul Railway was partially wrecked this morning near Belle Plain, 40 miles west of this place. The train was running at a speed of 50 miles an hour, and in a deep cut dashed into a flat car, which had been uncoupled from a switch engine about 2 miles up the track, and was coming down grade at a rate of 20 miles. The passenger engine was demolished and overturned. A fireman named Leakins was instantly killed, his body being taken out of the wreck badly mangled Engineer Thomas Keefe was severely scalded, but it is thought that he will recover.

Baltimore, O., June 14.—Mack Ryan, engineer in the Baltimore & Ohio yard at Fairmont, W. Va., was badly crushed about the hip to-day. His engine was detached from the train, and he was oiling and attempting to pass between the tender and cars. The engine at the farther end of the train suddenly pushed the train catching him.

Albuquerque, N. M., June 14.—Passenger train No. 4 was wrecked this evening about 10 o'clock, 3 miles this side of Holbrook, Ariz., a broken rail being responsible for the accident. Engineer Frost and Fireman Snyder leaped from the engine and sustained serious injuries about the breast and back, but neither is fatally hurt.

Antwerp, N. Y., June 15.—A work train on the Rome, Watertown & Ogdensburg Road jumped the track near this place yesterday. George Farmer, the fireman, was seriously injured.

Whitehall, N. Y., June 15.—Ed. Nichols, a fireman on the switch engine in the yards of the Delaware & Hudson Canal Company at this place, was struck by a locomotive this morning. He received a compound fracture of the right leg between the knee and ankle. Physicians think there is a possibility of saving the limb.

Baltimore, Md., June 17.—In a collision of freight trains on the Baltimore & Ohio Railroad, 38 miles east of Wheeling, W. Va., at an early hour this morning, Sherman Fisher, fireman of engine No. 1,208, was killed; an engineer named Gebring was badly injured. The accident was caused by freight train No. 89 over-running signals at Floyd Station. This train met the fifth section of No. 92 near Bellton. Both engines and several cars were wrecked.

South Norwalk, Conn., June 18.—Early this morning an engine, standing on a side track just north of the Housatonic Division station, was run into by a long mixed train, and both engines were badly wrecked. The fireman was seriously hurt.

Loveland, O., June 20.—There was a rear-end collision on the Baltimore & Ohio Railroad on a grade about 2 miles east of this place this evening. A freight train of 25 cars had broken in two. The flagman stopped the New York train, which had left Cincinnati, but the Pittsburgh express, which started from town about 20 minutes behind the other, could not be checked. It was flagged and the track lined with torpedoes. The rails, however, were wet, and the momentum of the train could not be overcome in time to prevent a collision. The engine drove into the rear coach of the New York train. No one in the coach was injured. The only person hurt was Frank Wright, fireman of the engine of the Pittsburgh train. He attempted to jump, but was caught between the locomotive and tender. He was mangled about the hips, and died at 11 P.M.

Troy, N. Y., June 21.—Ed. P. Campbell, a Delaware & Hudson engineer, was struck on the head this morning by a freight car standing on the side track between West Troy and Albany. Campbell had his head out of the cab window and did not see the car. The force of the blow knocked him from his seat in the cab and seriously injured him.

Worcester, Mass., June 21.—Arthur Ketchem, an overworked engineer on the Boston & Albany Railroad, who had fallen asleep at his post, ran into a car loaded with wool standing on a crossing. Signals had been set, but they were overrun. Just before the crash the head brakeman jumped to the engine, and, seeing the engineer asleep, reversed the engine and put on the brake. The fireman, who was on the other side of the engine, did not notice that the engineer was asleep. Train hands said that the crew had done five days' work in three days. No one was injured.

Galesburg, Ill., June 21.—The Chicago, Burlington & Quincy Road had a serious head end collision just east of Budder today. Owing to a wrong order from the operator, the fast stock train running east and a locomotive, running light, coming west met on a curve. The engineers jumped, but such was the speed of both trains that they were severely injured about the head, arms and legs. One fireman lost a part of one hand and sustained a fracture of the right leg. The other fireman was bruised about the head.

Meredith, Conn., June 22.—An extra freight train on the Consolidated Road broke in two on a grade 6 miles north of this city this morning. The engineer drove ahead to prevent a collision between the two sections, and ran into a Hartford freight. Nine cars were derailed, four of which were wrecked. Neither the engineer nor fireman were hurt.

Bristol, Conn., June 22.—There was a head-end collision on the New York & New England Railroad at six o'clock this morning between Forrestville and Bristol. Two engines were badly shattered, and two cars, a baggage and freight, were almost totally wrecked. Engineer John Beebe, running a passenger train, was injured, being badly shaken up and cut about the face. The freight train was moving up a grade at a slow rate of speed, while the passenger engine was running fast. The two engines were locked together.

Lafayette, Ind., June 23.—Fireman McKee, running between this point and Houston, was in the cab of his engine when the water-glass burst, and the pieces of broken glass flew into his eyes Medical attendance was immediately summoned, but the physician in attendance says that McKee will lose the eye.

St. Cloud, Minn., June 24.—An accident occurred this morning at Partridge, a small station on the Minnesota Railroad between Hinckley and Duluth. About one o'clock this morning a freight train, while running at a high rate of speed, ran into some cattle which were on the track, and an engine and large number of cars were derailed. Engineer Ingersoll was killed and his fireman very badly scalded.

Rochester, N. Y., June 23.—Two extra freight trains, west-bound, came into collision about half a mile west of Corfu, on the New York Central Road, about midnight to-night. The force of the collision threw about 25 cars from the rails, and the two engines were badly damaged. Charles Underhill, engineer on the first engine, had his arm broken and knee injured. Henry Schultz, fireman on the same engine, had his head cut and received internal injuries. J. Ransom, engineer on second engine, had his shoulder dislocated and wrist sprained. Tracy Stebbens, fireman on the second engine, escaped with slight scalp wounds. One trainman had his shoulder dislocated and arm broken, and another had his rib broken and shoulder sprained. The wreck was caused by the first train passing over from track 3 to 2 to avoid a wreck which had occurred on track 3 The second train was approaching rapidly, and Engineer Ransom states that the fog was so thick that it was impossible to see more than three rods ahead. The train struck the caboose with a crash, completely destroying a number of cars in the rear and also the engine of the rear train.

West Superior, Wis., June 24.—An extra freight, composed of 44 cars and running 30 miles an hour, ran into an ox asleep on the track near Partridge, 40 miles from Superior, at three o'clock this morning, and was wrecked. Every car was derailed, and 20 cars loaded with coal and merchandise were piled in a heap. Engineer J. Ingersoll and Michael McNannie were buried beneath the *débris*. J. Riley, a fireman, had an arm broken and was scalded about the abdomen.

Cincinnati, O., June 24.—An engine drawing an empty train of gravel cars left the rails on a trestle on the Cincinnati, Georgetown & Portsmouth Road, near Mt. Washington, this morning. Of the three men on it, Conductor David Homan and Fireman Philip King were fatally injured. Engineer Simonton jumped 10 ft. before the engine fell and was seriously hurt, but may recover.

Newton, Kan., June 25.—Freight train No. 42 of the Santa Fé system ran into a washout at a small station at Laige, 8 miles east of Emporia, to-night. The train was going at full

speed and was wrecked. Engineer Johnson lost an arm. The fireman had not been found at last reports, and is probably dead. The engineer of a dead engine that was being hauled by the train was badly injured. It was impossible for the engineer to see that the bridge was washed out in time to save the train.

Anaconda, Mon., June 26.—Engineer Elphinson, who was injured some time ago by the bursting of the water-glass in his cab, is in a very critical condition, being confined to his bed. An artery, together with several small veins, was severed by the glass, and it will probably be a long time before his arm is sufficiently well to enable him to return to duty.

Shamokin, Pa., June 26.—The locomotive used at the Enterprise Colliery exploded yesterday morning, seriously injuring Engineer Frank Depner. Fireman Peter Donoway was thrown 30 ft. down an embankment, but escaped with a few scratches. A defective fire-box was the cause of the explosion.

Chicago, Ill., June 27.—Four men were injured in an accident to a Big Four train on the Illinois Central Road at one o'clock this morning. The locomotive jumped the track, and, followed by a baggage car, rolled over in the ditch. Engineer W. T. Pearl was caught in the wreck, and received severe injuries about the head and side. He was able to crawl from the splintered cab and was sent home. William Ellis jumped when he felt the train on the ties and went through the window; he was cut about the head and face.

Communipaw, N. J., June 28.—Engine No. 19 of the Central Railroad of New York ran away from the engineer and off the end of the rails into the river to-day. When the men on the engine saw they were powerless to stop it, and that the plunge from the bank was inevitable, they jumped. There was an engineer, fireman and brakeman on the engine at the time. The engineer and fireman were not injured, but the brakeman was badly scratched and bruised.

Lancaster, Pa., June 29.—J. W. Lough, fireman on a freight engine, had a narrow escape from death at Rod Mill at Mountville and Roherstown about nine o'clock this evening. He was seated in the engine cab with his head out of the window when they passed a west-bound freight. Lough was struck on the head by the door of a refrigerator car, which had swung open. He was rendered unconscious by the blow, but was quickly restored by his engineer. He was badly cut about the face and head, a large gash being inflicted upon the forehead between the eyes, which extended down upon the nose. A piece of flesh was torn from the upper lip and tissues of the lower lip were torn from the bone.

Our report for June, it will be seen, includes 39 accidents, in which six engineers and nine firemen were killed, and 21 engineers and 23 firemen were injured. The causes of the accidents may be classed as follows:

Collisions	12
Struck by obstruction	3
Broken axle	1
Unknown	1
Falling from engine	4
Derailment	4
Train wrecking	1
Struck by passing train	4
Crushed between cars	1
Broken rail	1
Broken water-glass	2
Cattle on track	2
Washout	1
Explosion	1
Run-away engine	1
	39

PROCEEDINGS OF SOCIETIES.

Montana Society of Civil Engineers.—At the regular monthly meeting held on June 16, Mr. Cummings, in a discussion on the question of Manufacturing Industries of Montana, stated that the barley straw raised in the Gallatin Valley was particularly well adapted to the manufacture of paper, and it was understood that a paper-mill was soon to be erected at Manhattan. It was also stated that large deposits of iron ore existed in the vicinity of Great Falls. The other industries which were cited as being suitable to Montana was that of manufacturing pig iron, the only difficulty standing in the way at present being the quality of the coal that was available. Lead pipe and shot could be manufactured, and there was no good reason why silver bullion should not be refined and the lead that was in connection with it be used in some manufactory.

Engineers' Club of Cincinnati.—Underdrainage as a Structural Feature in Engineering Construction was the subject of a paper read by Colonel Latham Anderson at a recent meeting of the Club, which treated of the underdrainage of earthwork embankments as a means of promoting their strength and durability as engineering structures, the object of the drainage being to protect the embankment from sliding or washing from the action or presence of water, either by excluding it entirely or by leading away such as might or had accumulated.

Northwestern Railway Club.—At a recent meeting Mr. William McIntosh, of the Chicago & Northwestern Railway, presented a paper on fire-box steel, in which he said that the expense of renewing fire-box sheets is so great that railroad companies can afford to pay much more for this steel than they are now paying, if by so doing they can procure better material that would give longer service. The value of steel sheets used in repairing and constructing fire boxes represents not more than 10 per cent. of the cost of such repairs and renewals. Taking six weeks or 45 days, at the rate of $8 per day, as the value of the service of the engine while repairs are being made; the cost is $360. It is therefore obvious if a better quality of sheet could be procured, even at double the present price, it would be the part of wisdom to procure it. It would seem that the quality of fire-box steel has either deteriorated during the past 10 years, or else the conditions of service have so radically changed that it is destroyed much more quickly. Some years ago fire-boxes were removed from service which had been in use for from eight to 10 years, and now they are frequently taken out after four years of service. The fire-box that gave 10 years of service was of crucible steel, and the sheets that lasted but one year are from an open-hearth furnace. Crucible steel, of course, must be made from the very best material, and whether the open hearth process will admit of the use of inferior metal the author could not state; but complaints are general throughout the western country about the unsatisfactory service obtained from fire-box sheets. The probabilities are that if some enterprising manufacturer would produce a superior quality of steel there would be plenty of purchasers for it.

Engineers' Society of Western Pennsylvania.—At the regular meeting of April 18, Mr. G. Kaufman read a paper on an improperly designed chimney, which showed defects before it was completed owing to a high wind arising and straining it beyond its capacity for endurance. It was shown on examination that the chimney was built with one side flush with the edge of the foundation upon which it rested, so that when a wind was blowing in a proper direction an excessive strain was brought upon this side, and a settling occurred which caused the defects. In the conclusion of his paper he gives several rules for the construction of tall chimneys, which are as follows:

1. On compressible soils the foundation should be equally resistant.

2. *Weather.*—Shafts should be erected in the summer months, and on no account should the work be proceeded with in frosty weather.

3. *Progress.*—Shafts should be constructed at the rate of from 2 to 2½ ft. per day.

4. *Bend.*—There should be three or four courses of stretches to one course of headers to increase the longitudinal tenacity, which resists any force tending to split the chimney. Hoop iron built in the horizontal joints with ends turned in the vertical joints is very desirable and largely increases the longitudinal tenacity.

5. *Openings.*—Openings in the chimney should only be made at the bottom, and when such are made should be thoroughly buttressed to withstand the thrust. A better plan is to make them in the pedestal.

The London Metropolitan Board of Works have a set of rules governing the construction of tall chimneys, giving size and method of construction. They are as follows:

1. Every chimney shaft, for the furnace of a steam boiler, distillery or manufactory, shall be carried up throughout in brickwork and mortar, or cement of the best quality.

2. Every furnace chimney shall be built upon a bed of concrete to the satisfaction of the district surveyor.

3. The base of the shaft shall be solid to the top of the footings, and the footings shall spread equally all around the base by regular offsets to a projection on both sides equal to the thickness of the wall at the base.

4. The width, measured externally of a furnace shaft at the base, or at that portion immediately above the footings, shall be as follows:

If square on plan, at least one-tenth of the total height of the shaft.

5. Every furnace chimney shaft shall have a batter of 2½ in. at least in every 10 ft. of height, or 1 in 48.

6. The brickwork shall be at least 8½ in. in thickness at the top of the shaft, and for not exceeding 20 ft. below, and shall be increased 4½ in. in thickness for every 20 ft. of additional height measured downward.

7. No portion of the walls of a furnace chimney shaft shall be constructed of firebrick, and any firebrick lining to be used must be in addition to the thickness of, and independent of the brickwork.

8. Every cap, cornice, pedestal, string course or other variation from plain brickwork shall be in addition to the thickness of brickwork prescribed by the foregoing rules, and no cornice shall project more than the thickness of the brickwork at the top of the shaft.

The Engineering Association of the South.—At the meeting of the Engineering Association of the South, Nashville, Tenn., July 13, the subject of Smoke Prevention was presented by Professor Olin H. Landreth of Vanderbilt University. The paper discussed successively the causes, the effects of smoke and the remedies for it. Objectionable smoke comes mostly from bituminous coal, other fuels producing very little smoke. When fresh coal is thrown on incandescent coal, there at once begins the distillation of the more volatile hydrocarbons, which distilled matter is burned if sufficient oxygen is present and the temperature is sufficiently high, but which otherwise passes up the chimney as yellowsh fumes. As the fresh coal becomes more highly heated, the less volatile hydrocarbons are distilled, and are decomposed at a temperature much below that necessary for the combustion of the carbon liberated, about 2,000° F., a temperature so high as to give considerable margin of opportunity for this portion of the carbon to escape unburned. It is this free, unburned carbon in a finely divided state that, while incandescent, produces the luminous flame, and when cooled the clouds of smoke that issue from the chimney and afterward settle as soot. After the volatile matter is driven off the fixed carbon remains, and in burning produces but little flame and no smoke, since the particles of carbon are not detached from the solid mass till combustion takes place. As to the effects of smoke production, the fuel loss in the smoke itself is but small, estimated at one-sixth of 1 per cent.; but the causes of smoke are also the causes of imperfect combustion and consequent waste of fuel in the form of invisible gases, carbonic oxide and light hydrocarbons, and the presence of smoke indicates this parallel waste. Aside from the fuel waste, the effects of smoke outside the furnace make its abatement of public interest. It is authoritatively stated that the residuum of smoke in the lungs induces consumption of an incurable character, and that, in the city of Pittsburgh, Pa., the death-rate was 1.62 per 1,000 lower during the eight years in which the use of natural gas almost freed the city from smoke, as compared with the preceding eight years; and that since the partial return of smoke the rate has increased 2.57 per 1,000. Carbon in a finely divided state is an easy vehicle both for noxious gases and organic impurities. The insidious soot pervades and defaces public and private buildings and calls for fruitless efforts for cleanliness when cleanliness is impossible. Smoke is objectionable from the loss of light and increased cost of artificial light, also from the repression of æsthetic tendencies and consequent mental and moral discouragement. Consideration of the causes suggests the agencies and the mechanical devices for the prevention of smoke; these latter, so far as pertains to steam boilers, are classed as mechanical stokers, air flues in the walls and grate-bars, coking arches, dead plates, down-draft furnaces, steam jets for injecting air and mixing the gases, baffle plates and double furnaces. Smoke prevention must be accomplished by educating the public to consider smoke a nuisance that unquestionably can and should be abated, for the smoke producers are very slow to be convinced that this abatement is to their interest. Following the influence of public sentiment, laws are to be enacted and provision made for their enforcement and for furnishing to smoke producers, when desired, professional advice regarding the means and appliance for smoke prevention. The paper gives the statutes passed in Chicago, Cincinnati, Cleveland, Pittsburgh, New York, Rochester, Boston, Denver, the State of Ohio and the city of Birmingham, England, with statements of the success attained in preventing smoke in the localities; it also contains descriptions of various mechanical devices for smoke consumption, and closes with a list of literature on the subject.

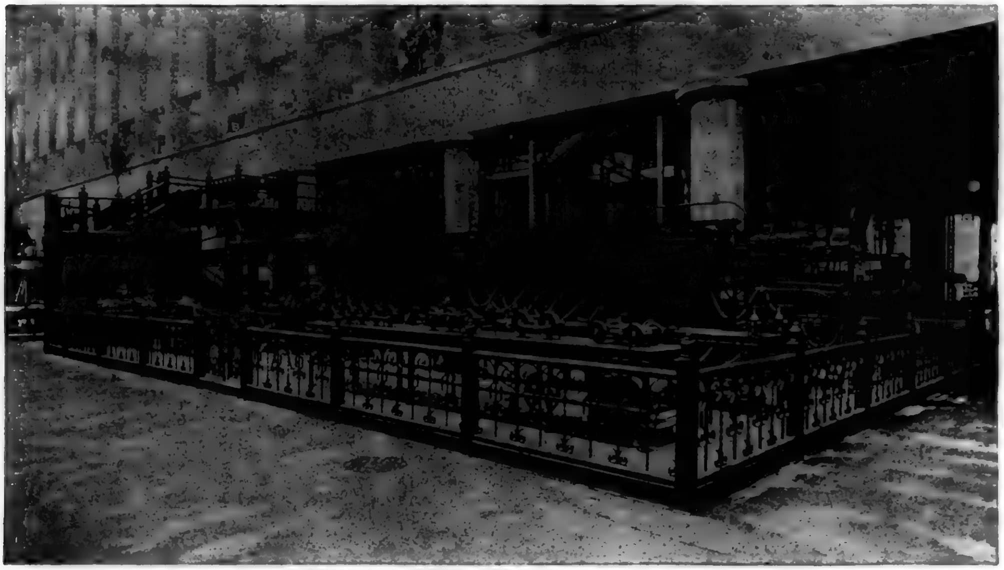


EXHIBIT OF THE WESTINGHOUSE AIR BRAKE COMPANY AT THE COLUMBIAN FAIR.

PERSONALS.

Frank Jones has been unanimously elected to the Presidency of the Boston & Maine Railway, to succeed Mr. McLeod, who resigned in May.

F. L. Garlinghouse has resigned his position as Chief Engineer of the Pittsburgh Bridge Co., and has opened an office in Pittsburgh, Pa., as Consulting and Contracting Engineer, having had over 20 years' experience in designing and manufacturing all kinds of structural iron and steel constructions.

OBITUARY.

John Whitmore, General Traffic Manager of the Fitchburg Railroad, died recently, aged 53. From 1854 to 1865 he

was employed on the Midland Railroad, in England. He came to Canada in 1866, and was employed on the Grand Trunk until he became General Agent at Buffalo. He was also General Manager of the International Fast Freight Line, later Agent for the Blue Line at Kansas City and General Agent of the Commercial Express Fast Freight Line at Chicago.

NOTES.

Test of Smokeless Powder.—A remarkable record of smokeless powder has been made at Sandy Hook. The Government has been testing the Leonard smokeless powder in a 3-in. field gun. A charge of 2 lbs. 3¼ oz. with a 13½ lb. shot gave the velocity of 2,230 ft. per second at 125 ft. from the muzzle, which is 300 per second more than had previously been obtained from the gun.

Broken Rails.—A remarkable case of rail fractures was recently brought to the notice of the Verein fur Eisenbahnkunde, of Berlin. On a certain section of one of the German lines no less than 81 broken rails were found in a single day during the past winter. The investigation which was ordered brought out the fact that on a very cold day the brakes were set on one of the cars of a coal train and were forgotten by the brakeman. The line has some heavy grades. The sliding of the wheels made large flat spots on the tires. After a time, it would appear, the brakes went off, releasing the wheels, and the latter, through the resulting pounding on the rails, produced the fractures mentioned. The correctness of this theory would seem to be borne out by the fact that there were always two fractures opposite each other in the two lines of rails.

Manufactures.

THE WESTINGHOUSE AIR-BRAKE COMPANY'S EXHIBIT.

We present an engraving showing the general appearance and arrangement of the exhibit of the Westinghouse Air-Brake Company at the Columbian Exhibition. The exhibit consists of 100 sets of freight-car brake apparatus erected on suitable supports, which are coupled together continuously, in substantially the same manner as if they had been placed upon 100 standard 34-ft. freight cars. The approximate length of 1¼ in. train pipe and connections used is 4,000 ft. In addition to this there is the exhibit of the necessary compressed air train signalling apparatus for the equipment of 12 passenger cars and a locomotive. The various devices are shown with a section removed, in order to admit of a ready explanation of their internal arrangements. There is also erected, on a suitable framework, a form of reinforced brake apparatus, which, when applied to a railroad train, is intended to develop a maximum braking force of about 200 per cent. of the weight of the several vehicles when running at a high rate of speed. Provision is made in this apparatus for the automatic reduction of pressure with the reduction of speed in the train.

It will be seen from an examination of the photographs that the American Brake Company also occupy a portion of the space allotted to the Westinghouse Air-Brake Company, and they therein exhibit several forms of driver-brake apparatus, intended for various types of locomotives, with four, six and eight driving-wheels coupled. They also exhibit a combination of driver and engine truck-brake apparatus.

THIRTY-TON ELECTRIC LOCOMOTIVE. BUILT BY THE GENERAL ELECTRIC COMPANY.

THIRTY-TON ELECTRIC LOCOMOTIVE.

In our issue for May we illustrated a 90-ton Electric Locomotive designed for the Baltimore & Ohio Railroad. We now illustrate the first electric locomotive of any considerable size in the United States, and the first practically operative high-speed electric locomotive in the world adapted to the steam railroad, which has recently been completed at the Lynn works of the General Electric Company, and will shortly be exhibited at the World's Fair.

It is a 30-ton locomotive, designed for a normal speed of 30 miles an hour, primarily intended for operation on elevated railways and for passenger and light freight traffic on less important steam roads. It is of compact construction, solidly and substantially built, and runs on four 44-in. wheels. Its dimensions are: 16 ft. 6 in. long, 11 ft. 6 in. high, 8 ft. 4 in. broad, having its draw bars 2 ft. 6 in. from top of rail—the Manhattan Elevated Railroad standard height. The draw bar pull is calculated at 2,000 lbs.

The propelling power is furnished by two electric motors of especial design and construction, each axle being provided with one motor. The motors are gearless, and are supported on spiral springs resting on the side frames of the locomotive truck. This method of suspension leaves the wheels free to adjust themselves to the irregularities of the roadbed, and

consequently the wear to both tracks and motors is diminished. The motor fields consist of massive iron castings to which the hollow field spools are bolted. The armatures are of the iron-clad type, having each separate winding imbedded in a mica-lined slot cut into the curved surface of the laminated iron armature body. The axles of the locomotive pass through the hollow shafts on which the armatures are mounted. These shafts rest in bearings of the motor frame, and are connected to the axles by universal couplings, which allow of freedom of motion in all directions. The commutators are of massive construction, and there are four sets of brushes to each commutator.

The motors are controlled by means of a series parallel controller set up in the interior of the cab. This device embodies all the latest improvements made in this type of apparatus by the General Electric Company. Under test it is found that the series parallel controller allows of a more gradual and easier starting of the electric motor, and the speed can be more delicately and instantaneously controlled than in the case of the steam locomotive.

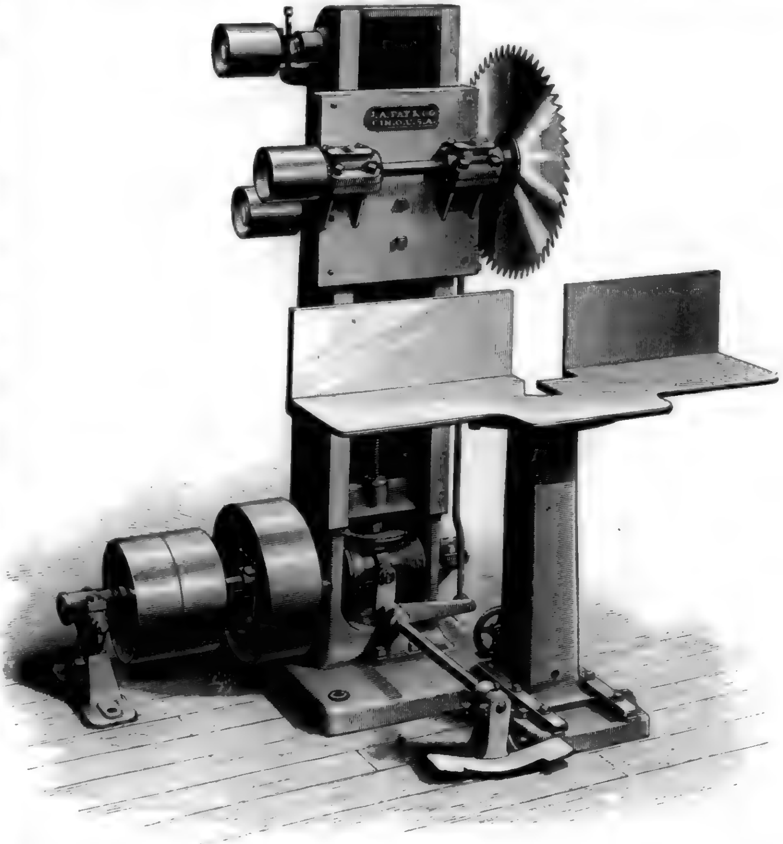
The truck, suspended from the journal boxes, is constructed of heavy I-beams, and forms the foundation for the locomotive cab, of sheet iron, of symmetrical design, and so curved off as to diminish the atmospheric resistance as far as possible. The interior is finished in hard wood. Two sliding doors are placed at each side of the cab, and the windows are so arranged as to permit of an unobstructed view in all directions. There is ample space in the cab for the motor man's movements, and it affords him considerably better protection than that usually vouchsafed the steam locomotive engineer. The position of the headlights is shown in perspective view.

The air for the brake is supplied by a special electrical air compressor, which also operates the whistles. This air pump has an oscillating cylinder of 6 in. in diameter, with a 6-in. stroke, supplying 6,000 cub. in. of air per minute at 70 lbs. pressure. The motor is similar to the N. W. P. 2½ in general appearance, but is wound for a higher speed. The normal speed of the armature shaft is 675 revolutions, and of the crank shaft of the pump 110 revolutions. The dimensions of the air compressor are: Length, 41 in.; width, 16½ in.; height, 25 in. The pump motor is controlled by a special rheostat. This, by an intermediary device, is automatically regulated by the air pressure. This locomotive has been designed for a normal speed exceeding 80 miles per hour.

The evolution of the use of the electric locomotive will probably follow along the lines dictated by expediency and favoring conditions.

VERTICAL CUTTING-OFF SAW.

THIS machine, which is built by J. A. Fay & Company, of Cincinnati, O., is designed for special kinds of work required in car building. It is built on a heavy column having a broad sole plate securing a large floor support. The face of the column is planned to receive the saw carriage and arbor which is gibbed to it, and actuated up and down by a screw of coarse pitch driven by gearing at the bottom. By pressing the foot upon the treadle, which is shown at the front of the machine, the clutch is thrown into action, which drives a screw running in a nut on the saw carriage raising or lowering the same as the right or left-hand side of the clutch is brought into action. The saw arbor is driven from the counter-shaft at the base and is belted with a belt running over the idle belt shown at the top of the column in such a way that the tension of the belt is the same at whatever point on the column the carriage may be placed. The position of the counter-shaft is such that the belting may be in any direction. The table for the material to rest upon is independent of the main structure of the machine. It is gibbed to the sole plate, and has an adjustment to and from the column by means of a handwheel and screw. The top has a radial adjustment for angle sawing and gaining purposes.

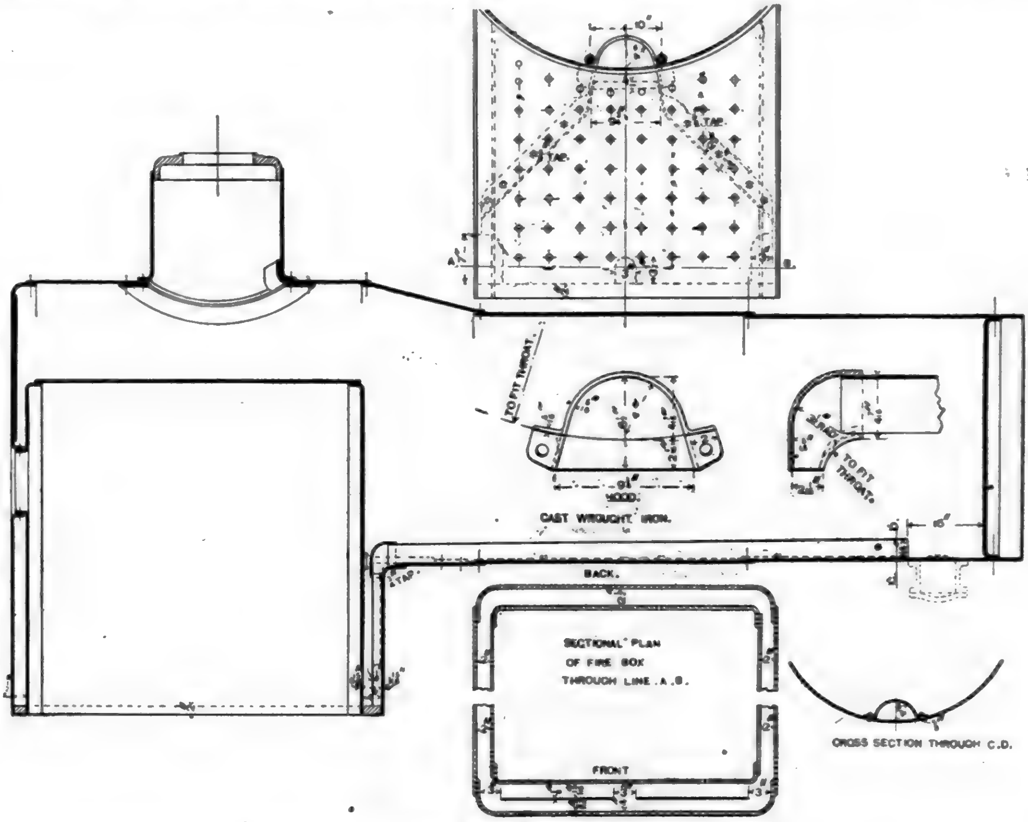


VERTICAL CUTTING-OFF SAW.

STEAM HEATING ON THE EASTERN RAILWAY OF FRANCE.

FOR a number of years past the Eastern Railway of France has been making experiments with a system of heating for their passenger cars which bears the stamp of considerable novelty and at the same time does not appeal very strongly to American instincts and American practice. The fundamental idea of the system is that of the use of steam, taken from the locomotive for the purpose of obtaining the desired temperature, and mingling it at the same time with a quantity of air under pressure taken from some independent source of supply. When the work was undertaken this supply of compressed air was derived from the main reservoir of the air-brake, but it was soon found that the single pump used for the brake had an insufficient capacity to supply the needs of both the system of heating and the brakes; therefore a second and independent pump was put upon the engine for the pur-

pose of supplying the compressed air for heating. The idea seems to be that air will maintain a uniform pressure in the pipes throughout the whole length of the train, and that when the train is cold the time required for the steam to reach the last car is very much less when it is mingled with compressed air than when steam is admitted alone. This time has been cut down on certain tests from 95 minutes to about 25 minutes. There are automatic arrangements for removing the drip and the condensation of the steam automatically, and at the same time allowing the excess of air to escape so that there is a continual inflow from the front end. The arrangement of piping in the cars is very similar to ours, with the exception that it is more complicated and more troublesome to manage, as, instead of the single cock which is used for controlling the temperature of our American cars, there are three, which are to be upon a company who, in this country, should cut off all supply of heat on its passenger trains when the temperature of the outside air was up to 59°. Therefore the system of heating merely means that people are not to be allowed to freeze to death. This explains the reason why the admission of air into the pipes is necessary. They must have a circulation, and the amount of steam admitted for actually heating the cars is so slight, and the temperature of the latter is so low, that circulation with steam alone would give them a great deal of trouble by condensed water freezing in loops and pockets; but with the admission of compressed air there is a continual flow through the pipes and this freezing is avoided. At the same time, the system as a method of heating would be considered a most decided failure were the French practices to be introduced into this country.



MACK'S BOILER CIRCULATOR.

opened successively, according to the temperature of the external air. The piping in the car is arranged with three loops, and these are buried in the floor and covered with a plate, and this plate is what is supposed to warm and heat the car; but in reality it would seem, from a description which was recently published in the *Revue Generale de Chemins de fer*, that it merely acts as a foot-warmer, and can have but comparatively little influence upon the temperature of the air in the car; but of this there is no report and we have no data.

Our opinion regarding temperature of the car is derived from the table giving instructions to train men. It will be remembered that we have just said that there are three cocks to be opened for each car in order to admit the full heating capacity of the system. The instructions, then, as given to the employés for this purpose, are, that if the temperature is

23° Fahr. or less, all three cocks are to be opened.

If it is between 23° and 41°, two cocks are to be opened.

Between 41° and 50°, one cock is to be opened.

Between 50° and 59°, one cock is to be opened at intervals.

Above 59° the heat is to be cut off entirely.

We can imagine the complaints that would be showered

MACK'S BOILER CIRCULATOR.

We illustrate a new device of boiler circulator, which has recently been brought out by Mr. W. B. Mack, of 92 White Street, East Boston, Mass., for the purpose of facilitating the circulation in the water leg of locomotive boilers, a working model of which was on exhibition at the recent Master Mechanics Convention at Lakewood. The device shown is a reproduction of a working drawing taken from one of the boilers now in use on the Boston & Albany Railroad. An examination of the engraving will show that it consists essentially of a pipe led along the bottom of the shell of the boiler, turning with the throat-sheet and passing down the front water leg to the mud ring, spreading out from the top to the side sheet. After passing over the curve of the throat-sheet, it practically divides the water leg into two equal parts, with a sheet of ¼-in. metal held in position by angle plates riveted to the throat itself. At the bottom this plate has three openings, one in the center 3⅝in. wide and 3½ high, and one on either side 7 in. and 3 in. wide.

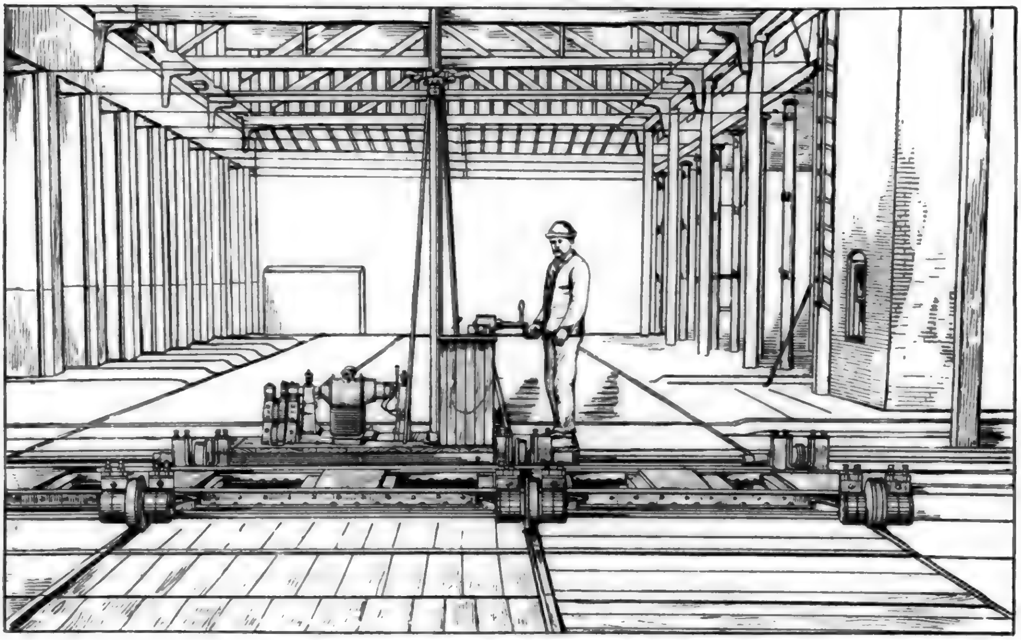
The action of the device is as follows: When fire is burning in the fire-box the water next the throat and side sheets is heated and rises; the cold water at the forward end of the shell then flows back through the passage at the bottom, down the face of the throat sheet, and out through the three holes at the bottom of the sheet just described, thus delivering a constant current of comparatively cold water into each of the side water legs, and also into the center of the front water leg, thus establishing a perfect circulation.

The general dimensions of the device are clearly given on the engravings. In the model which was exhibited at Lakewood it was shown that the rapidity of the circulation was increased with the draft of steam taken from the boiler. Thus, when the boiler was standing still, with no emission of steam whatever, the circulation through the pipe, which was visible by means of a glass, was very sluggish; but the moment a valve was opened allowing the escape of steam, whether it was a blower in the stack or through the safety-valves, the rapidity of the circulation increased very markedly, until it was so rapid that the eye could merely see that the water was rushing through the glass with great velocity. It is said on the Boston & Albany road, where this device has been in use for some time, that it is giving satisfaction.

ENGLISH AND AMERICAN LOCOMOTIVES ON THE NEW SOUTH WALES RAILWAYS.

The following extract from an address delivered at the recent annual meeting, by Professor Warren, the retiring President of the Royal Society of New South Wales, the leading scientific association in Australasia, has been sent to us by a correspondent in that far-off country. We know nothing of the circumstances under which the trials of locomotives were made, excepting what is stated in the following quotation.

In reference to the rolling stock of the New South Wales lines, Professor Warren asserted, "that during the last year a number of engines had been introduced of exceptional power for passenger and freight service, the object aimed at being the economical working of the traffic over the heavy grades and sharp curves, which were characteristic of our railway system. Formerly two engines were employed for passenger trains, whereas now one engine not only did the work better, but effected a very large saving in working expenses. Twelve of these engines were made by the Baldwin Engine Company, America, and 50 by Messrs. Beyer & Peacock, of Manchester, England. One of the engines made by the American firm was carefully tested on the steep grades of 1 in 40 and 1 in 30 between Picton and Mittagong, on the Southern line, and the maximum performance during the trial consisted in hauling a train weighing 156 tons (in addition to the weight of the engine and tender) up a long grade of 1 in 40 at a speed of 19¼ miles an hour. A trial of one of the English engines was made on the Sutherland bank, Illawarra line, where a train weighing 225 tons (in addition to the weight of the engine and tender) was hauled up a grade of 1 in 42 at a speed of 20 miles an hour. The ordinary load of these engines over the southern lines was 165 tons, and the speed attained daily on the 1 in 40 grade 22¼ miles an hour, and on the 1 in 30 grade the speed fell to 18¼ miles an hour. The commissioners were also making an enormous improvement in the safety of working heavy goods trains by fitting them with the new Westinghouse automatic quick-acting freight brake."



FLUSH TRANSFER-TABLE. BUILT BY EDWARD C. WHITE.

FLUSH TRANSFER-TABLE.

We illustrate a flush transfer-table, which has been put upon the market by Edward C. White, of 556 West Thirty-fourth Street, New York. The table is intended to be operated either by an electric motor, as shown on the engraving, or by hand power. As far as we know, it is the only absolutely flush turn-table which has as yet been designed. The rails for the transfer-table are exactly on the same level with the rails in the running tracks. The framing of the table is of iron channel bars with boxes for carrying the wheels, as shown on the engraving. This, of course, necessarily raises the rail of the table above the rails of the track, and the approach to these is by means of an inclined plane carried on the table and projecting out beyond its limits over the standing tracks. These strips are of iron 2 ft. 7 in. long, and are beveled down so as to give a gradual rise from the incoming rail to the table rail. When the table is in motion these inclines spring up and clear the rails by about a quarter of an inch, but when the table is stopped and a car is started to be run upon it, as soon as the wheels strike these inclines they are sprung down and rest against the rail. Their length is sufficient, so that the limit of the resilients of the metal is not exceeded by the distance which they are obliged to deflect, hence they always maintain their proper height. The table is intended for street-car purposes, and none have as yet been built for the heavier cars of steam roads. The table is so thoroughly cross-braced that there is no danger of its being thrown out of line or out of square. The table's length over the inclines at each end is 27 ft. 10 in., while the total length of the table proper is 22 ft. 6 in., which is an ample length for the ordinary electric or cable cars that are now used.

AMERICAN ENGINEER AND RAILROAD JOURNAL.

(Formerly the RAILROAD AND ENGINEERING JOURNAL.)

PUBLISHERS' DEPARTMENT.

PENNSYLVANIA RAILROAD EXHIBIT AT THE WORLD'S FAIR.

A Complete Illustration of the Progress of American Railroads.—Striking Contrasts between the Past and Present.

The World's Fair visitor who finds his way into that vast enclosure by the Sixty-fourth Street entrance will come almost immediately upon a building as architecturally attractive as any of the minor structures in all the great White City by the lake; a building classical in detail as well as in general conception, standing in the midst of a plateau of greensward with walls the tint of old ivory, and garnished with flags that reflect the brighter hues of the rainbow. While it is an annex, so to speak, of the great red and green and gold Transportation Building across the way, it is an annex complete in itself, and within and without exhibits in an exhaustive manner never before attempted, much less accomplished, the beginning, progress, and development of railroading in the United States as exemplified by the Standard Railroad of America. It is, in fact, the Pennsylvania Railroad Company's own edifice, and it presents an interesting and scholarly showing of that corporation's history from the first inception of one of its component parts in 1815, when the first charter was granted to a railroad company in America to construct a road from Trenton to New Brunswick, N. J., to the present time, when it controls nearly 10,000 miles of road penetrating 13 States, and with termini in New York Harbor, at the National Capital, in three great cities of the Ohio Valley, and at five of the great lake ports.

While the building's main façade is perhaps the more beautiful of the two 140 ft. sides of the structure, the rear view will doubtless prove the more attractive to the student of railroad progress, in that it presents, with its attendant features, an excellent reproduction of a model Pennsylvania Railroad station of the present day, with signal tower, tracks, ballast, switches, frogs, overhead foot-bridge, fences, and gates. The tracks in themselves are as indicative as anything else of the marked development in this branch of mechanics in the last 60 years, the exhibit showing, in juxtaposition with as fine a specimen of the standard Pennsylvania rail of 1892 as has ever been rolled, pieces of the Camden & Amboy rail of 1831, of the rail used on the old Portage Road over the Alleghenies, and of the very crude wood and iron rail with which the Madison & Indianapolis Road was originally laid. Some idea of the contrast may be had when it is stated that whereas the Camden & Amboy rail weighed only 35 lbs. to the yard, the standard rail of to-day, of which the examples shown are 100 ft. in length, weigh 100 lbs. to the yard, being nearly three times as heavy.

Upon the tracks is another contrast even more marked. Probably the most conspicuous, and certainly the most interesting, object in the display is the original *John Bull* train, where here rests after its 1,000-mile journey across the Continent from New York. The old engine itself—the oldest in America—which was constructed by George Stephenson, in England, and brought to this country in 1831 for use on the Amboy Division of the Pennsylvania Railroad, stands there to-day precisely as it was in 1836, after having had added to it such improvements as were then suggested to the minds of the American engineers. Its weight, with its somewhat cumbersome tender, is only 32,100 lbs., as against 100 tons, the weight of the ordinary standard passenger locomotive of to-day, and beside the modern machine, of course, it looks very much like a toy. The passenger coaches, glistening with a fresh coat of green paint, are so low that a tall man cannot stand upright within them; their brakes are worked by means of handles similar to those on the horse-cars of the present time, and the only method of lighting them is by a tallow dip in each end of each car. As example of the magnitude to which the railroad cars of to-day have attained, no better choice could have been made than the selection for exhibit, side by side with this tiny passenger train, of the two tremendous vehicles on which the mammoth Krupp guns were whirled from Baltimore to the Exposition; the manner in which the guns were carried being shown by means of full-size models, made of staff, of the standard 16-in. and 10-in. guns, such as are now used by the United States War Department.

This policy of contrast, which is so apparent without the building, is carried throughout the entire display, and the interior, with its relief maps, charts, models, lay figures, photographs, and relics, gives a better idea of the wonderful growth of the greatest railroad system of the country than could possibly be had in any other way. The walls of the great marble-floored hall, into which the visitor may enter from either the front or the rear, are lined with handsome mahogany show-cases, while the columns, so arranged as to form a colonnade on each side, are surrounded by folding frames for the display of thousands of exhibits that could be shown to advantage in no other way.

In arranging the display, the smallest details have not been neglected, and as an indication of the thoroughness with which these little matters have been looked after, the labelling of the objects with a descriptive label in five languages is especially noteworthy.

In the centre of the building, under the dome, upon a platform shaped like a Greek cross, are three relief maps that are certain to attract no little notice. They illustrate the changes in the methods of crossing the Alleghenies from the year 1832 to the present time, and have been prepared with such great care as to have won words of high commendation from scientists, whose attention has been called to them. One of these in particular, the largest of the three, which is 12 ft. long by 4 ft. wide, and which shows the old portage and the new portage roads, together with the present line of the Pennsylvania Railroad, including the Horseshoe Curve, Allegrippus, and the district of the Johnstown flood, is especially valuable as being the first and only relief map ever made of that section. The original map, from which the basis of the present work was obtained, was one which belonged to the late J. N. DuBarry, Vice-President of the Company. It was in lead-pencil, never having been filled in in ink, and was traced, so the legend runs, by President J. Edgar Thomson himself. The other two relief maps, or models which form two arms of the cross, show the Horseshoe Curve and Plane No. 1, with canal-boat, cars, and locomotives.

The rest of the floor space between the colonnades is dotted with pedestals and platforms upon which are models relating particularly to the developed system of transportation of to-day. On one side, for instance, is a beautiful reproduction in miniature of the double-decked ferry-boat *Washington*, one of the fleet plying between Jersey City and New York. In every particular the model maker has closely followed the original, and has succeeded in turning out a piece of work as nearly perfect in every detail as it is possible to imagine. On gala days it is proposed to decorate this little vessel with bunting, and arrangements have been made to light the interior with electric lights precisely as the boat from which it is copied is lighted. The method of handling freight cars in New York Harbor is shown here in the same way by means of models of a tug-boat and float. Toward the other end of the building are lay figures in uniform of the several classes of employés of the Company.

An object of considerable interest to many is a perspective map, 33 ft. long, showing the position of each train in motion on the Pennsylvania system at six o'clock on the morning of Columbian Day, October 21, 1892.

With regard to the arrangement of the exhibits in the cases, and the swinging frames, considerable care has been exercised to carry out the fundamental ideas of grouping and contrast. One corner has, therefore, been given up to those features which have especially to do with motive power, another is devoted to engineering and maintenance of way, a third relates particularly to the relief department of the Company, and in the remaining quarter of the spacious room are general relics.

A feature of much interest to the visitor is the Bureau of Information, which will be maintained in the building. Experienced employés will be placed in charge, who will not only answer questions concerning the exhibits, but will give information relative to train schedules in current use, and other matters of interest to the traveler.

Complete as this exhibit of the Pennsylvania Railroad Company would seem, it is lacking in one or two essentials; but this lack is made up, the visitor will find, when the General Transportation Building comes in for inspection. There the Company has deemed best to exhibit its finished products of 1892, in the shape of cars, turned out at its own Altoona shops, and accordingly shows three specimens of most excellent work-

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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EDITORIAL NOTES.

A CURIOUS objection to the use of the telephone is said to exist in the mind of the Sultan. He will have none of it in any of the cities of his dominions, on the ground that his subjects are all too ready to intrigue and conspire against his happiness, and he does not propose to allow the introduction of any device whereby this conspiring can be made easier. It is stated that this prejudice is so deep-rooted that those interested in telephone development have ceased to make any efforts to secure franchises in the land of the Turk.

RAPID transit for New York still seems to have a lingering life. The latest development is that the Rapid Transit Commission has cut loose from the Manhattan Elevated Railway, and are making some sort of proposals to build independent elevated railways. This is said to have brought the Manhattan to a reconsideration of the terms proposed before, and there the matter is again resting. It would be hazardous to make any predictions looking toward a speedy settlement, and it is probable that the first of January will see the end of another year and nothing accomplished.

WE would call especial attention to the brief report that appears in another column of the Aerial Navigation Convention recently held in Chicago. Not that there are any novelties in the shape of facts set forth in the report, but because the position taken by those most interested in the matter is so clearly elucidated. It is not expected that express speeds will be attained, or that aerial navigation will soon reach a stage of development that will present an attractive field for commercial investments, but simply that aerial navigation promises to become an accomplished fact though it may not supplant the locomotive and the ocean steamer.

WE mentioned in our last issue that the Government was after something marvelous in the shape of a torpedo boat, and now we have to record that the Board appointed to report on the designs submitted consider that the one of them which most nearly meets the requirements should be built. Of the two that may be considered as competitors, the Holland is designed with a strength sufficient to resist a submergence of 70 ft. and the Baker for one of 150 ft. The recommendation, however, is that the former boat be built. No action has as yet been taken by the Department of Construction. Should the boat accomplish what is expected of it, there will be an element introduced into naval warfare that will go very far toward making the operation of a blockading fleet inoperative.

A CURIOUS case of objectionable interference between a railway and its employés is given by an English correspondent of the *Independent*. In order to avoid the responsibilities of the Employers' Liability Act of 1880, the Brighton Company instituted an insurance fund, which any of its employés were at liberty to join, but were not compelled to. But in so doing the applicant signed a contract freeing the employer from all liability under the act. The premiums were so low that the company was called upon to make up a large deficit, but the accident insurance was complete and covered every form of accident, whether it came within the provisions of the act or not. But the idea was an unpopular one among the labor organizations, or at least among the leaders of such organizations, and now there is a movement, despite the protests of the employés, to make such a form of contract illegal. In other words, the labor leaders propose that all men shall be saved in their own peculiar and particular way.

MONTHLY MEETINGS OF MECHANICAL ENGINEERS FOR TECHNICAL DISCUSSION.

FOR a year or more past various members of the American Society of Mechanical Engineers have expressed a desire that more frequent meetings of the members should be held, which should be devoted to the discussion of subjects pertaining to their various occupations. A sort of half-hearted and unorganized effort of this kind was made in the winter of 1891–92, and even under the unfavorable conditions which then prevailed a number of the meetings proved to be very entertaining, instructive and profitable, and indicated what might be accomplished if they were conducted by an intelligent committee who felt an interest in their success. For several years past what are called "reunions" have been held each month during the winter, which were attended by members, their wives, sisters, cousins and their aunts. Some one has disrespectfully designated these meetings as "*petticoteries*," but even with this title many members found them very agreeable, and doubtless there would be much regret—in which the writer would share—if they were discontinued. They were, and probably always will be, social in their character. There are quite a considerable number of members—just how many has not yet been ascertained—who feel that purely social enjoyment should not be the only aim in the meetings of a society like that of the Mechanical Engineers. While they are quite willing and ready to dress, and talk, and eat, and smile and flirt—if need be—at the petticoteries, they feel that meetings for the consideration of subjects for which the Society was organized, if held at least once a month, would be both pleasant and profitable.

To such a scheme the objection has been made that the Society is a national one, and that it would be impolitic to organize and hold a series of meetings in which a large proportion of the members could not participate on account of their distance from New York. It is a curious fact that those who urge this objection most strenuously are the most active at the Society's sociables, which have been held monthly. On the principle upon which objection is made to holding monthly meetings for technical discussion, non-resident members might object that we, who live in New York, are the recipients of an undue proportion of smiles and allurements which are so graciously disseminated at the meetings referred to.

It is also objected that the rules of the Society make no provision for monthly technical meetings, although it is specifically stated in Article 36 that "other regular meetings (besides the annual one) of the Society shall be held in each year at such time and place as the Council may appoint." Still, as there is some objection, on the ground of expediency, the members who have felt an interest in holding monthly meetings during the coming fall and winter, for the discussion of technical matters, have considered the advisability of making them not meetings of the Society, but of *members* of the Society. There is at present no reason why two or three, or two or three dozen members, may not meet in the rooms which the Society occupy and discuss any subject whatsoever. The plan that has been proposed is a very simple and direct one, which is to organize a committee which shall take charge and direction of the meetings. This will consist in selecting subjects for discussion, inviting competent persons to open and start it, appoint a chairman to preside, select the time and place for holding the meetings, issue notices and announcements of them, and exert themselves generally to promote their interest and profit.

The practice and past experience of a kindred society, which now meets in the Mechanical Engineers' hall, may be quoted as supplying a type of meetings which might be imitated. The society referred to is the Railroad Club. As originally constituted it had no constitution, rules, or membership. The only organization was a committee, which originally was self-appointed, and conducted the proceedings and filled vacancies which occurred. It now has a constitution and by-laws, membership and officers, and a regular organization. In its early years, however, the committee referred to took entire charge of everything. For each meeting a subject was selected by the committee which it was thought would interest railroad men. A person who was an expert on the subject selected was then invited to make a short address not exceeding 20 minutes or a half hour in length, in which interesting facts, theories or experiences were presented. This served to excite the interest of the audience, stimulate the thoughts of those present, and steer the discussion.

A formal paper is apt to be a bore to a large proportion of an audience. It often happens in the meetings of the Railroad Club that machines, tools, models, drawings, samples or other objects are presented and exhibited at the meetings which serve to excite interest. When this is once accomplished discussion always follows.

One result of holding these meetings at an appointed time each month is, that those who are interested in them and who live outside of New York arrange their business so as to be here on the date of the meeting, and thus these monthly occasions become reunions of people living in different parts of the country and who have like interests. The same results would be sure to follow similar assemblages of mechanical engineers.

Of course if such meetings should meet with favor, it might be desirable to hold them either under the auspices of the Society itself or to form some regular organization to take charge of them, but in the beginning this is not needed. Members of the Society who feel an interest in this scheme are solicited to signify their approval or disapproval by communicating with the editor of the AMERICAN ENGINEER.

CYLINDER PROPORTIONS.

THE following inquiry comes from a correspondent:

"Assume that a new locomotive is to be designed for a given service. Knowing the maximum grades, radii of sharpest curves, maximum weight of train and speed of same, the maximum train resistance is approximately determined. The boiler pressure, stroke and diameter of drivers are known.

"On page 595 of 'Meyer's Modern Locomotive Construction,' I find the following formula for finding the diameter of the cylinders

$$d = \sqrt{\frac{T \times D}{P \times S}};$$

where T = tractive force; D = diameter of drivers in inches; P = mean effective pressure; and S = stroke in inches.

"Now, the question which perplexes me is, What value should be given to P?

"If P is taken at .90 of the boiler pressure, as recommended on page 541 of 'Catechism of the Locomotive,' for slow speeds and late cut-offs, then at high speeds and short cut-offs the value of P will be so greatly diminished that the engine will be unable to perform the work for which it was designed. In other words, the cylinders will be too small for expansive working.

"On page 4 of the AMERICAN ENGINEER AND RAILROAD JOURNAL, January, 1893, I find a table showing approximately the mean effective pressure in per cent. of boiler pressure, due to speeds of from 6 to 75 miles per hour, with drivers of from 50 to 78 in. diameter.

"Could not the value of P in the above formula be calculated approximately from this table, and the diameter of cylinders determined accordingly?

"Having thus obtained the diameter of cylinders, the maximum tractive force at starting could be calculated with an assumed maximum effective pressure .90 boiler pressure. Then tractive force × 5 = adhesive weight.

"Would it be practicable to assume that the locomotive is to perform its maximum work with a given point of cut-off, release and compression; lay out the theoretical indicator diagram and calculate the mean effective pressure therefrom? The mean effective pressure thus obtained could only be approximately correct, as the clearance at this stage of the design would be unknown and the back pressure could only be assumed.

"Is there any arbitrary mean effective pressure used by builders in designing the cylinders of express, freight and switching locomotives?"

Our correspondent's difficulty seems to arise from a desire to make a locomotive which will exert its maximum tractive force while working steam expansively during a considerable proportion of the stroke. We will assume that in doing this that he wants to cut off steam at three-eighths of the stroke, and expand it during the remaining five-eighths. The average pressure of steam in the cylinders with this point of cut-off would be less than 70 per cent. of the boiler pressure. Consequently, in order to get cylinder capacity enough to turn the wheels, the cylinder must be made larger than would be necessary if steam was worked full stroke, or as near full stroke as an ordinary slide-valve will permit. If they are thus enlarged, then if steam is worked full stroke at any time, the cylinders would have too much capacity for the adhesion of the wheels, and they would then be liable to slip. In other words, if the cylinders of a locomotive are made large enough, so that it can exert its maximum trac-

tive effort when cutting off at a small fraction of the stroke, it will be liable to slip its wheels when working full stroke.

It is essential to work steam full stroke in starting, because when the valves are cutting off steam short, the engine may, and frequently would, stop in positions in which both valves would be closed, or rather the admission ports of both cylinders would be closed. It would then be impossible to start.

Still another difficulty at low speeds would be that in cutting off short, the rotative effect exerted on the wheels is so irregular that an engine could not exert its maximum power. The best that we can do, then, is to proportion the cylinders, so that when working full stroke the pistons can exert just enough tractive power so as to slip the wheels. After making all the deductions for loss of pressure in the cylinders, and it is found that all we can count on is 90 per cent. of the boiler pressure as effective pressure in the cylinders when steam is cut off as near full stroke as the ordinary slide-valves will permit.

If the cylinders were increased in size and we attempted to exert more power at high speeds, it would then be impossible to supply enough steam. It is found that when the cylinders are proportioned so that they can just slide the wheels in starting and when working full stroke, that there is then always cylinder capacity enough to use up all the steam that can be supplied at high speeds, even when cutting off short.

STANDARD RAIL SECTIONS.

Engineering News of August 17 publishes engravings of the forms of "rail sections recommended as standard by the Committee on Standard Rail Sections of the American Society of Civil Engineers." These were presented with a report at the business session of the late Engineering Congress at Chicago. The same paper also publishes an editorial on the subject of the report, in which the editor congratulates all the world on the fact that this committee has recommended that the radius of the upper corners of the rail-heads shall be $\frac{5}{16}$ in. instead of "$\frac{1}{4}$ in. or thereabouts," as recommended by the Master Car-Builders' Association.

Ten or 12 years ago a paper was read at one of the meetings of that Association, calling attention to the great incongruity in the forms of the sections of rails and wheel-treads and flanges which then existed, and recommending that those portions of the rail-heads which come in contact with the flanges of the wheels should be made to conform to or fit the flanges, on the principle "that the wear of surfaces in frictional or rolling contact is in inverse proportion to their area."

This recommendation, the editor of *Engineering News* says, resulted in "a decided and widespread tendency to conform to this demand," which, he says further, "it is now all but unanimously admitted was wholly without any rational foundation."

This is followed by the observation "that Mr. A. M. Wellington . . . now claims the credit of having individually stopped an unchecked current of practice toward an alleged erroneous theory."

Our quotation marks have been carefully used.

Now what was this great stroke of genius of which the editor of *Engineering News* was the author, and on which he felicitates himself so complacently? His achievement consisted in substituting a radius of $\frac{5}{16}$ in. for describing the form of the corners of rail-heads for one of $\frac{1}{4}$ in. (which was the original proposition).

It recalls one of Thackeray's stories. When he was in this country he chanced to occupy the same seat with a loquacious passenger in a railroad car, who, on learning how famous a person his companion was, announced as his claim for distinction that "*my father was the first man who introduced c-o-l-d pressed castor-oil.*"

The report of the committee referred to above was received too late for a full discussion of it here, but we may have something more to say of it hereafter. Most of those who compose the committee which made the report before us are very able men. So far as we know, however, only one of them has had his chief professional training and experience in the department of mechanical engineering of railroads, and he is now in retirement. Most of the others are eminent civil engineers. Surely in the consideration of what may be called the conjunction of the civil with the mechanical engineering of railroads, the mechanic should have had some voice. While no criticism of the work of the committee will be attempted now, attention may be called to one fact—the original committee consisted of seven members, who recommended a radius of $\frac{1}{4}$ in. for the corners of the rails. When five new members were added to the committee, the radius was increased to $\frac{5}{16}$ in., or made 25 per cent. greater. The problem propounded is, if five additional civil engineers increase the radius 25 per cent., how much would it be increased if there were an equal representation of competent mechanical engineers on the committee?

NEW PUBLICATIONS.

BEESON'S INLAND MARINE DIRECTORY. By Harvey C. Beeson. (276 pp., $6\frac{1}{4} \times 9\frac{1}{4}$ in.) Detroit, Mich.

The first 29 pages of this work contain a table giving the class, name, tonnage, date when built, where built, name of owner or manager, and residence of owner or manager. The extent of the shipping interest on the great lakes may be known that this list includes over 1,800 vessels. Besides this there is a list of about 350 steam-vessels of under 5 tons burden. Another list of sailing-vessels includes over 1,300 of these. A variety of other data and information of interest to fresh-water mariners, of those interested in the traffic of the lakes, is scattered through the book. There are also a number of good and some indifferent half-tone engravings of lake steamers, yachts and sailing-vessels, and also a goodly number of advertisements.

THE COAL TRADE. *A Compendium of Valuable Information relating to Coal Production, Prices, Transportation, etc., at Home and Abroad, with many Facts worthy of Preservation for Future Reference.* (121 pp., 6×9 in.) By Frederick E. Saward, Editor of the *Coal Trade Journal*. New York.

This volume contains first a review of the coal trade for 1893. This is followed by a convenient table showing the annual production of coal in the United States and Territories for the years 1889, 1890, 1891, and 1892. In round numbers the total of this production was 132, 140, 150 and 155 millions of tons for the years respectively. Following this table is a series of sketches of the different coal-fields and their production, the traffic of the different cities. The latter part of the book contains a miscellaneous collection of information concerning coal and coal traffic of varying degrees of interest and value. The book does not seem to have any very well-defined

plan, and is a collection of miscellaneous data relating to the coal traffic, much of which is valuable and cannot be found in an equally convenient form elsewhere.

THE GREAT LAKES REGISTER OF SHIPPING; *also Rules and Tables of Scantlings for the Construction of Steel Ships.* (59 pp., 8½ × 11 in.) By Joseph R. Oldham, N.A. and C.E., Chief Surveyor, Cleveland, O.

The first part of this volume the author describes as "a book of rules for the construction of lake steamers, with formulæ for ascertaining the size of shafting for marine engines and estimating horse power and displacement; formulæ and rules for riveting joints; tables of weights of materials, areas of circles, etc.; and general particulars of construction, including dimensions of boilers, 'wheels,' cylinders, etc., of all the steel, iron and composite steamers on the Northwestern lakes."

The latter part is a register of shipping on the great lakes. In this all the vessels owned by different companies, firms and individuals are given under the names of such parties; the names of the vessels, whether screw or paddle, tonnage, dimensions, size and steam pressure of boilers, diameter and stroke of cylinders, diameter of screws, date when built, and where and by whom built.

The rules given for the construction of ships have apparently no other authority than that of the author. The data embodied in the tables will be of much interest and value to all who are concerned in the lake shipping.

THE OFFICIAL RAILWAY LIST. *A Complete Directory of the Presidents, Vice-Presidents, General Managers and Assistants, General and Division Superintendents, Chief and Assistant Engineers, Secretaries, Treasurers, Auditors, Traffic Managers, General Freight Agents, General Passenger and Ticket Agents, Baggage Agents, Superintendents of Telegraph, Purchasing Agents, Fuel Agents, Car Accountants, Superintendents of Motive Power, Master Mechanics, Master Car-Builders, Master Car Painters, Foremen of Repairs, Roadmasters, etc., of Railways in North America, and Hand-book of Useful Information for Railway Men.* Twelfth Year. (479 pp., 4½ × 8 in.) Chicago: Railway Purchasing Agent Company.

The title of this book is so long that it leaves but little room for any other notice. There seems of late to be a *penchant* for long titles in books, and some authors transfer their tables of contents to their title-pages. The practice cannot be commended.

Not much need be said of the excellent directory before us, excepting that it is bigger, has more names in it—and more advertising—than ever before. It has a stout, plethoric look of prosperity that will make some publishers envious. Those who want the names and addresses of railroad officials will find this one of the most convenient books which give that kind of information.

KNOTS, SPLICES, HITCHES, BENDS AND LASHINGS, *Illustrated and Described.* By F. R. Brainard, Ensign U. S. Navy. (76 pp., 4 × 6 in.) New York: Practical Publishing Company.

The title of this book describes its character. It illustrates and tells how to make a great many different kinds of knots, splices, hitches, bends and lashings with ropes of different kinds. The method of doing this is illustrated by a series of outline diagrams, not of the best kind, but sufficient for the purpose. It is intended not only for seafaring men alone, but for wayfaring men as well, who, it is said in the introduction, "may profit by the knowledge of the subject, and may with advantage put the knowledge to practical every-day use." The information it contains will also be relished and valued by yachtsmen, boatmen, and canoeists. It might be added that every mechanic, especially those who have anything to do with the erection of heavy work, would be greatly benefited by a knowledge of how to tie ropes most effectively.

The book contains directions for tying ropes in 128 different kinds of ways. This is followed by tables giving the circumference, weight per foot, working and breaking strength of hemp and iron and steel wire ropes. The tables are followed by 12 pages of definitions.

The book is considerably padded, to make as much showing as possible with a little matter. It is printed on very thick paper, the pages are small, each one having only 112 words, so that the whole book contains only 8,400 words. As the price of the book is $1, its contents might be quoted at 84 words for a cent, which makes this kind of knowledge come high.

BOOKS RECEIVED.

Professional Papers of the Corps of Engineers of the United States Army. No. 26.

Local Engineering Data for St. Louis. Compiled by the Engineers' Club of St. Louis.

The Compass. Vol. II. New York: William Cox, Editor; Keuffel & Esser, Publishers.

Poor's Manual of the Railroads of the United States for 1893. H. V. & H. W. Poor, New York.

Bulletin of the United States Geological Survey. Nos. 82, 83, 84, 85, 90, 91, 92, 93, 94, 95 and 96.

Electricity up to Date. Third Edition. By John B. Verity. New York: Frederick Warne & Company.

The Michigan Engineers' Annual, containing the Proceedings of the Michigan Engineering Society for 1893.

Molesworth's Pocket-Book of Engineering Formulæ. Twenty-third Edition. London and New York: E. & F. N. Spon.

The Law of Incorporated Companies Operating under Municipal Franchises. Vols. I, II and III. By Allen Ripley Foote. Cincinnati, O.: Robert Clarke & Company.

United States Geological Survey. By J. W. Powell, Director. Eleventh Annual Report, 1889–90. Part I, Geology; Part II, Irrigation.

The Chilean Revolution of 1891. By Lieutenant James H. Seares, U. S. N., and Ensign B. W. Wells, Jr., U. S. N., Washington, D. C.: Office of Naval Intelligence, Navy Department.

Monographs of the United States Geological Survey. By J. W. Powell, Director. Vols. XVII, XVIII and XX, with Atlas to accompany the Monograph on the Geology of the Eureka District, Nevada, by Arnold Hague.

TRADE CATALOGUES.

LIGHT CARS. Sheffield Car Company, Three Rivers, Mich.

CHAPMAN VALVE MANUFACTURING COMPANY'S CATALOGUE, 1893. Boston, Mass.

PITTSBURGH LOCOMOTIVE WORKS exhibit at the World's Columbian Exhibition.

GENERAL CATALOGUE of Worthington Pumping Engines, Steam Pumps and Hydraulic Machinery.

CATALOGUE OF RAILWAY, STEAMSHIP AND STATIONARY ENGINE APPLIANCES. J. T. Connelly, Milton, Pa.

OUR EXHIBIT, World's Columbian Exposition. Brown & Sharpe Manufacturing Company, Providence, R. I.

WORTHINGTON STEAM-PUMPING MACHINERY at the World's Columbian Exhibition. Manufactured by Henry Worthington.

FRAZER & CHALMERS, of Chicago, send us over 30 different catalogues describing the various kinds of machinery they manufacture, which relates chiefly to mining and metallurgical operations.

ROOT IMPROVED WATER-TUBE BOILER, Abendroth & Root Manufacturing Company, New York. This is a six-page (6 × 15½ in.) folder, with excellent wood-cuts, illustrating this form of water-tube boiler. A concise description of the details of the boiler is appended.

THE C. W. HUNT COMPANY, of New York, have issued a descriptive catalogue (6¼ × 9¼ in., 24 pp.) of their "industrial" railways. These are intended for mines and factories of all kinds. The book is elaborately illustrated. The same Company also send a description (8 pp.) of their exhibit at the Columbian Exhibition.

BROOKS LOCOMOTIVE WORKS, Dunkirk, N. Y., have also issued a descriptive volume (6¼ × 10 in., 30 pp.) of their exhibit at the Chicago Fair. It contains an engraving and historical sketch of their works, an announcement of the facilities which the Company has for doing work, and illustrations and dimensions of the locomotives they have on exhibition.

THE WORCESTER DRILL GRINDER, manufactured by the Washburn shops of the Worcester Polytechnic Institute, Worcester, Mass. This is a small pamphlet (5¼ × 8 in., 20 pp.) describing the various kinds of drill grinders which are made at the shops of the Worcester Polytechnic Institute. It is illustrated with a number of good engravings, and gives sizes, prices and other information which a buyer will be likely to want.

E. W. BLISS COMPANY, of Brooklyn, N. Y., have sent us a number of circulars (9 × 12 in.) which describe the different kinds of presses made by them. One of these (8 pp.) describes the "Stiles" Drop Hammers. The others relate to Double-Crank Power Presses (20 pp.), Toggle Joint Drawing Presses (16 pp.), "Open-Back" Power Presses (12 pp.) and the "Stiles" Power Punching Presses (12 pp.). These are all illustrated with excellent wood-engravings, are well printed on coated paper, which does not smell bad, as the paper of some of the other catalogues we have noticed does.

THE WEIR FROG COMPANY, Cincinnati, O., manufacturers of frogs, switches, crossings, etc.

The catalogue of this Company is quite an elaborate volume (4¾ × 8¼ in., 233 pp.), which opens on the short end. It is illustrated by a large number of excellent outline engravings which are made by the wax process, and also a considerable number of wood-cuts. As we have frequently pointed out, the best treatises on many subjects are now trade catalogues. The book before us is an example. While it makes no pretensions to an exhaustive treatment of the subject to which it pertains, there is a great deal of valuable information in it which cannot be obtained from any other source. The book concludes with a number of useful tables relating to turn-outs, switches, frogs, crossings, etc.

THE ROGERS LOCOMOTIVE COMPANY, Paterson, N. J. (8 × 11½ in., 117 pp.) This Company has just issued a new catalogue of the locomotives they manufacture. It begins with a very brief history of the works, with engravings of them as they were in 1832 and as they are in 1893. This is followed by a general description, or rather blank general specifications of a locomotive. A very excellent and clear chapter on The Tractive Power of Locomotives is then given, with directions for calculating the tractive power of locomotives and the resistance of trains. The remainder of the book contains 50 engravings of the different types of locomotives built by this Company, with tabular statements of their dimensions and capacity. Most of the illustrations are very good half-tone engravings, although a few of them are wood cuts.

This same Company have also issued a descriptive pamphlet (6¼ × 11 in., 17 pp.) of their exhibit at Chicago. The different engines they have on exhibition are illustrated by very good half-tone engravings and diagrammatic views giving the principal dimensions of their locomotives. It gives, in a very convenient form, all the information which an engineer is likely to ask for who visits the exhibit.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD LOCOMOTIVES. Mr. William Buchanan, Superintendent of Machinery and Rolling Stock of this line, has just issued a very convenient little book (3 × 8¼ in., 54 pp.) giving the general dimensions, weight, etc., of the locomotives on that road. It begins with a convenient table in which the speed in feet per second and the time in seconds per mile is given for different speeds per hour. Opposite this is a half-tone engraving of the Columbian flyer train, made from a photograph taken at full speed. After this is an engraving of the reproduced *De Witt Clinton* and its train, with the dimensions of that engine. A half-tone engraving and the dimensions of the celebrated engine 999 occupies the next pages. The rest of the book is occupied by 22 very convenient diagrammatic engravings of the different classes of engines used on the New York Central Railroad, with their dimensions arranged in tabular form. The book can conveniently be carried in the pocket, and altogether is a model of its kind. The only fault we can find with it is that the pages are not numbered, which might be an inconvenience in referring to them.

CATALOGUE AND TESTIMONIALS OF COLD SAW CUTTING-OFF MACHINES, Newton Machine Tool Works, Philadelphia. This catalogue, which is a 60-page pamphlet, 6¼ × 9¼ in., will probably be a revelation to many readers, who will be surprised to find what a variety of the kinds of machinery which it describes is made. Twenty-two different kinds of such machines are illustrated, and a number of sizes of some of them are built. The manufacturers say:

"The Cold Saw Cutting-Off Machine has long since ceased to be an experiment, and has been proved by practical operation to be very much of a success, not only for cutting off round, square or flat bars, but for the general run of cutting and for forge work, architectural iron works, rolling mills and general machine-shop work. We know of no machine shop that has not work enough to make one of these tools pay for itself in a short time.

"The saws are hollow-ground, and are made in three grades of teeth: fine teeth for hard material; medium sized teeth for ordinary work, and coarse teeth for heavy or soft stock. The saws run in a bath of oil or soda water, keeping them cold and lubricating the cutter."

COMPARISON OF THE PRACTICAL RESULTS OBTAINED BY THE USE OF THE WROUGHT-IRON FORGED WHEELS, AS MADE BY THE ARBEL'S ESTABLISHMENTS AND THE WHEELS OF SEVERAL AMERICAN TYPES. The Anonymous Manufacturing Society of the Arbel Establishments, Rive de Gier, France. (6 × 9½ in., 52 pp.)

To a very considerable extent this pamphlet is descriptive of the exhibit of the Arbel's Establishments at the Columbian Exhibition. It also gives a historical sketch and description of the works, and "a few words"—which are descriptive—"on other systems of wheels." An interesting historical notice on the Wrought-Iron Wheels is also given, with a description of the method employed at the Couzon's Works in France, which are the Arbel's establishments. The last part of the volume contains a dissertation on Railroad Wheels by M. L. Durant, and gives the results of tests made upon the request and according to the indications of Mr. Ernest Polonceau, Chief Engineer of Machinery of the Orleans Railway. The object of the pamphlet is to show the superiority of the Arbel wrought-iron wheels over others in use in this country and elsewhere. The merits of wrought-iron wheels do not seem to have ever been fully appreciated in this country. Their record of service, endurance and reliability in Europe should be an interesting and profitable study for American railroad engineers.

EXHIBIT OF LOCOMOTIVES BY THE BALDWIN LOCOMOTIVE WORKS, Philadelphia. What has been said of the Brooks and Rogers exhibition volume might almost be repeated of the one which the Baldwin Company have issued. Theirs is, however, larger than either of the others (7¾ × 10½ in., 78 pp.). The frontispiece to the book is a half-tone engraving showing the interior of their erecting shops, and another engraving shows the outside of their works.

The first chapter is a sketch of the history and capacity of their establishment. In all 13 locomotives are illustrated and described. Of these more than half are of the Vauclain compound type. The engraving, printing and paper are all excellent.

There is one criticism of the engravings in this and in the Brooks volume which we think might be justly made. The photographs were nearly all taken from a point a little in front of the engines, and they are shown on an angle looking toward the back end. The result is that the size of the smoke-boxes, chimneys and trucks are all exaggerated in relation to the other parts, and the effect is somewhat the same as when a countryman has his picture taken and protrudes his hands and feet too far forward. The picture of the magnificent *Decapod* engine, opposite page 63 of the Baldwin catalogue, as an example, looks—to speak in convivial vernacular—as though it had been on a "tear" and was suffering from a "swelled head." The front of the engine, including the smoke-box, chimney, etc., which are not its most impressive parts, are exaggerated, and the imposing proportions of the engine are to a considerable extent lost. The same thing is true of the view of the "double-ender" opposite page 17, and to a less degree of the *Columbia* on page 26. The great driving-wheel sof this machine, grouped close together under the middle of the boiler, are the most striking features of this machine. If the camera had been placed exactly opposite to these, they would have had their full value in the picture, and the front and back ends of the engine would have appeared in their proper relation to the other parts. As it is, the front truck wheels of the *Columbia* are shown much larger than the back ones, which give the representation of this engine a sort of bobtailed appearance which takes away much of its dignity. The most striking view of a locomotive, it is thought, is a square side elevation, and if such a photograph could be made, which would be an orthogonal projection, it would make the most effective picture which could be taken.

DESCRIPTIVE AND ILLUSTRATED CATALOGUE (4¾ × 6¾ in., 390 pp.) OF THE PRATT & WHITNEY COMPANY, Hartford, Conn. This is a new catalogue recently issued by this well-known company, who are engaged in the manufacture of the lighter classes of machinists' tools. The extent of their facilities for doing work may be known from the following extract from the preface of the book before us:

"In the machine shops are 400 lathes of various kinds, 115 planers, 85 drilling machines, 120 milling machines, 18 screw machines, 13 gear and rack cutters, 10 boring mills, and 200 other machines, in addition to the tools used in the pattern shop. When all these are running the concern can give employment to about 950 men."

To give an idea of the kind of work which this Company does, we would be obliged at least to copy the index to its catalogue. This occupies 5½ pages, and is little more than an enumeration of the different kinds of tools which are manufactured. Nearly every page of the book has an engraving on it, some of them more than one, so that the catalogue contains nearly or quite 400 engravings. These are all wood-cuts, the great majority of which are of the best kind, although here and there the trace of process work may be seen.

Looking over the pages of this book and the knowledge thus acquired of the elegant tools and appliances supplied by this Company will or should stir the mechanical soul—if there is such a thing—of any good machinist to its very profoundest depths.

The book has been published in a very convenient form, and is filled with useful information from one end to the other.

LOGARITHMIC TABLES. By Professor George William Jones, of Cornell University. Fourth Edition. London: Macmillan & Company; Ithaca, N. Y.: George W. Jones.

This work is a new edition of the logarithmic tables of Professor Jones, which have been before the public for several years. It is entirely reset in new type, with a larger page, and is a decided improvement over the previous issues. The logarithms and other tabular functions are given to six decimal places, and the author has partly obviated the objection, often made with much justice to such tables, that interpolation is difficult, by giving on the margin multiples of the differences. In the early part of the table, however, all these could not be printed in the space at disposal, and hence all objections are not fully removed. It is our opinion that logarithmic computations are most satisfactorily made, either with five-place or seven-place tables, but the work of Professor Jones is certainly one of the best six-figure tables with which we are acquainted.

THE JACK'S RUN VIADUCT.

To the Editor of the AMERICAN ENGINEER:

DEAR SIR: I have seen in your July edition a description and illustration of the Jack's Run viaduct, which has been put up lately under my direction in the vicinity of Pittsburgh for an electric road of the Pleasant Valley Railroad Company. The article contains a good many errors, and I consider it therefore my duty to correct some and add a few additional facts, which you will be kind enough to publish in your next issue.

After the company had already several bids and plans for said viaduct I was appointed to take charge of the work. The cheapest plan was accepted under the condition that same would be approved by the engineer. After a correct survey and lay out for the pillars a recalculation for the whole structure was made.

The trestle posts were made more rigid by increasing the latter from $\frac{1}{16}$ to $\frac{1}{8}$ and by substituting stiff cross-braces for rods. Various other sections have been increased, and after specifications for substructure and superstructure had been prepared, the contract price was altered accordingly and details worked out under my supervision.

As will be seen by the formulæ (in July edition) the viaduct was constructed very economically. Said formulæ are unhappily given wrong, but any bridge engineer may easily correct them.

The viaduct is owing to the stiff cross-bracing very rigid, and the electric cars run over it with unrestricted velocity.

The cost of the structure, including everything, is about two-thirds of the figure as given in your July issue.

The viaduct was to be constructed within three months from the time the contract was let, but owing to a severe winter it took just four months longer.

Truly yours,

PITTSBURGH, PA. HERMANN LAUB, C.E.

NOTES AND NEWS.

A Correction.—In our last issue, on page 366, we illustrated a safety plate under the running board, and credited the same to the Southern Pacific Railway. It should have been credited to the Canadian Pacific; and a letter received from the mechanical department states that they have never had an occasion where one of these plates has been pierced.

Large Steel Plates.—Some of the largest steel plates ever made in England have been turned out at the works of the Cousett Iron Company, Durham. They measure 60 ft. 2 in. in length, 50 in. in width, and $\frac{11}{16}$ in. in thickness. They are for use in the construction of some large cattle ships which are being built at West Hartlepool for a firm in the United States.

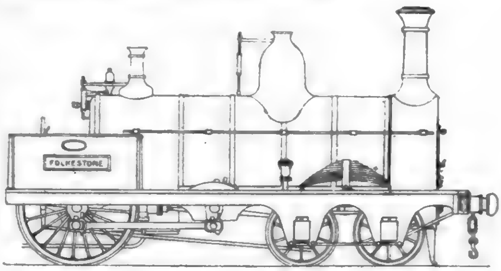
Franklin Avenue Freight Station in St. Louis.—In publishing the engravings and description of this structure last month, one of the most important facts in relation to it was omitted, which was that it was designed and built under the supervision of Mr. George S. Morison, C.E., whose office is in the Temple, Chicago. This omission was accidental, and we apologize for the oversight to all and everybody to whom our apologies are due.

Air-brakes for Street Cars.—For some time past a street railway company of St. Louis, Mo., has been making careful tests of air-brakes on six of its cars, and the test is said to have been so successful as to warrant its adoption. The brake is the same in principle as that used on steam railways, with the exception of the method of pumping the air. This is done by a pump attached to the axle of the car. As the axle revolves it operates the air-pump by means of cogs. The maximum pressure is 40 lbs. to the inch, and this can be obtained while the car is running a distance of 200 ft. The car can be stopped 10 times in the space of one block without exhausting the air.

The Great Mersey Bridge.—Plans have been drawn up for what, when finished, will be one of the world's greatest bridges. This new structure is to cross the river Mersey at Liverpool. It will be of arched suspension type in three spans, the roadway being suspended from an arch. Each span will have a clear waterway of 1,000 ft., the center span having a clear headway of 150 ft. above high water of ordinary spring tides. The bridge will allow for a roadway 40 ft. in width, sufficient for at least four lines of wheel traffic, and two outer footways, each 7 ft. 6 in. wide, the roadway being laid with wood and the footpaths with granolithic pavement. In addition to the provision for ordinary wheel and passenger traffic, an overhead electric tramway is to be constructed along the center of the road.

Naval Premiums.—A calculation has been made at the Navy Department in regard to the premiums paid to builders of naval vessels during the present year. Beginning with the *Bancroft* in January, the Government paid her constructors, the Moores, of Elizabethport, N. J., \$45,000 for exceeding her speed. Then followed the *Detroit*, which earned \$150,000 for the Columbian Iron Works, of Baltimore. The *New York* came next with the largest sum won yet, when, by reeling off 21 knots, or one better than called for, she won \$200,000. The *Machias*, by her fine performance, also gained \$45,000 for the Bath Iron Works. The *Columbia*, which will have her speed trial in the next month, may also gain a large bonus for the Cramps, but this will be a more difficult thing than winning \$200,000 on the *New York*. The *Columbia* will have to make 21 knots an hour to fulfill the contract, and to get her speed up a knot better will require an enormous and continuous burst of steaming qualities.

The Folkestone Locomotive.—Mr. Clement E. Stretton recently sent the following data regarding the Folkestone locomotive, which we illustrate, to the *English Mechanic*, to whom we are indebted for the engraving.



The engine has inside cylinders, an intermediate crank-shaft without wheels, and a driving-wheel of 6 ft. diameter. On the South-Eastern Railway it took 44 tons at an average of $65\frac{1}{2}$ miles an hour, and attained $73\frac{1}{4}$ on a falling gradient.

The eight engines of this class afterward had the second pair of leading wheels removed, and a pair of driving-wheels placed upon the crank-axle. Thus converted to four wheels coupled engines, they continued at work many years.

Determination of the Quality of Vulcanized Rubber.—M. Vladimiroff recently read a paper before the Technical Institute of St. Petersburg, giving the results of his experiments which were made for the purpose of establishing rules to be followed in determining the quality of vulcanized rubber. He stated that chemical analysis was unsatisfactory, and that all tests should relate to the physical properties. From a long series of experiments he reached the following conclusions, from which the regulations of the Russian Navy relative to the acceptance of vulcanized rubber will be made:

1. Rubber ought not to give the slightest sign of cracking when bent double, after having been left for five hours in a closed air-chamber where the temperature is 125° C. The pieces used for the test should be $2\frac{3}{4}$ in. thick.
2. Rubber should not contain more than one-half of its own weight of the metallic oxides, and should stretch to five times its own length before breaking.
3. Rubber which is free from all foreign matter with the exception of the sulphur which has served for its vulcanization should stretch seven times its original length before breaking.
4. The permanent stretch measured immediately after rupture, should not be more than 12 per cent. in excess of the length of the piece as it was first submitted to the test. These test pieces should be about $1\frac{1}{4}$ in. long, $\frac{1}{8}$ in. to $\frac{1}{4}$ in. wide, and $\frac{1}{4}$ in. or more thick.
5. The suppleness can be determined by calculating the percentage of ash obtained by incineration; this determination can also furnish the basis of the choice which is to be made between different rubbers for various uses.
6. Vulcanized rubber ought not to harden under the action of low temperatures.—*Revue Scientifique.*

THE CONFERENCE ON AERIAL NAVIGATION.

BY A. F. ZAHM.

AMONG the various congresses recently assembled at the Memorial Art Palace, the International Conference on Aerial Navigation, held under the auspices of the General Engineering Congress, proved beyond expectation interesting and successful. Some 45 papers were contributed, covering many of the problems of aeronautics and aviation, and presenting the observations and results of experiments of experts in many countries of the world.

The effort of the committee to secure the co-operation of serious and capable men, to accumulate facts and positive knowledge rather than speculations or descriptions of projects, was abundantly rewarded, as the following programme will indicate:

TUESDAY, AUGUST 1ST.

HALL 7–2.30 P.M.

AERIAL NAVIGATION CONFERENCE.

Opening Address:

O. CHANUTE, Chairman Organizing Committee.

SCIENTIFIC PRINCIPLES—JOINT SESSION.

PAPERS AND DISCUSSIONS.

"The Internal Work of Moving Air," S. P. Langley, Secretary Smithsonian Institute, Washington, D. C.

"Anemometry," S. P. Ferguson, Blue Hill Meteorological Observatory.

"Aviation," A. Goupil, Civil Engineer, Narbonne, France.

"Supporting Surfaces in Air," C. W. Hastings, Civil Engineer, deceased.

"The Air Propeller," H. C. Vogt, Naval Experimenter, Copenhagen, Denmark.

"The Screw Propeller," C. W. Hastings, Civil Engineer, deceased.

"The Elastic Fluid Turbine as a Motor," J. H. Dow, Mechanical Engineer, Cleveland, O.

"Motors for Flying Machines," C. W. Hastings, Civil Engineer, deceased.

"Materials of Aeronautic Engineering," R. H. Thurston, Director Sibley College, Ithaca, N. Y.

"Strength of Aeronautical Materials," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.

"Forms for Flying Machines," C. W. Hastings, Civil Engineer, deceased.

"Behavior of Air Currents," George E. Curtis, Smithsonian Institute, Washington, D. C.

"Meteorological Observations," H. A. Hazen, Weather Bureau, Washington, D. C.

WEDNESDAY, AUGUST 2D.

HALL 7–2.30 P.M.

AERIAL NAVIGATION CONFERENCE.

SECTION A—AVIATION.

PAPERS AND DISCUSSIONS.

"Observations of Birds," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.

"Gliding Flight," J. Bretonniere, Engineer and Observer, Constantine, Algeria.

"Soaring Flight," E. C. Huffaker, Observer, Bristol, Tenn.

"Sailing Flight," C. W. Hastings, Civil Engineer, deceased.

"Theory of Soaring Flight," Ch. de Louvrie, Engineer, Combebizou, France.

"Theories of Soaring and Sailing," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.

"Theory of Sailing Flight," A. M. Wellington, Editor *Engineering News*, New York City.

"The Advantage of Beating Wings," Ch. de Louvrie, Engineer, Combebizou, France.

"Equilibrium of Flying Machines," C. W. Hastings, Civil Engineer, deceased.

"The Equipoise of Flying Machines," A. F. Zahm, Professor Nôtre Dame University, Indiana.

"Experiments in Flying Machines, Motors, and Cellular Kites," Lawrence Hargrave, Experimenter, Sydney, New South Wales.

"Suggestions and Experiments," F. H. Wenham, Engineer, Goldsworth, England.

"Methods of Experimentation," A. P. Barnett, Experimenter, Kansas City, Mo.

"Learning How to Fly," C. E. Duryea, Mechanical Engineer, Peoria, Ill.

"A Programme for Experiments," L. P. Mouillard, Observer, Cairo, Egypt.

"Gliding or Soaring Devices," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.

"Various Experiments," E. C. Huffaker, Observer, Bristol, Tenn.

"Experiments with Hexagon and Tailless Kites," W. A. Eddy, Experimenter, Bayonne, N. J.

"Kite Experiments," J. Woodbridge Davis, New York City.

"Flexing of Bird's Wing in Flight," B. Baden Powell, Lieutenant Scotts Guards, England.

"Designing of Flying Machines," J. D. Fullerton, Major Royal Engineers, England.

THURSDAY, AUGUST 3D.

HALL 7–2.30 P.M.

AERIAL NAVIGATION CONFERENCE.

SECTION B—BALLOONING.

PAPERS AND DISCUSSIONS.

"Manufacturing Hydrogen Gas Balloons," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.

"Natural Gas Balloon Ascensions," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.

"Flotation *vs.* Aviation," Professor de Volson Wood, Stevens Institute, Hoboken, N. J.

"Navigable Balloon Flight," C. W. Hastings, Civil Engineer, deceased.

"Manœuvring of Balloons," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.

"Systematic Investigation of Upper Air," M. W. Harrington, Chief of Weather Bureau, Washington, D. C.

"Balloon Signals," Ch. Labrousse, Aeronaut, Paris, France.

"Observations from Balloons," C. C. Coe, Aeronaut, Ridge Mills, N. Y.

"Balloon Meteorology," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.

"Design of Navigable Balloon," General W. Hutchinson, British Army, Silverdale, England.

"Ten Miles up in the Air," De Fonvielle, Paris.

Mr. O. Chanute, Chairman of the Organizing Committee and of the first day's meeting of the Conference, announced in his opening address that the purpose of the Congress was to collect and place on record the knowledge obtained since the last similar international congress, held at Paris in 1889, to give students and experimenters an opportunity of meeting and corresponding, and to promote concert of action among the various persons who take an interest in the problem. He gave substantially a summarization of the progress thus far attained in the propulsion of balloons and in the construction of flying machines, stated the probable limitations in the capacity and usefulness of each, and indicated the proper character and domain of future effort. He said:

"It is well to recognize from the beginning that we have met here for a conference upon an unusual subject; one in which commercial success is not yet to be discerned, and in which the general public, not knowing of the progress really accomplished, has little interest and still less confidence.

"The fascinating, because unsolved, problem of aerial navigation has hitherto been associated with failure. Its students have generally been considered as eccentric; to speak plainly, as "cranks;" and yet a measurable success is now probably in sight with balloons—a success measurable so far that we can already say that it will probably not be a commercial one—while as to flying machines proper, which promise high speeds, we can say that the elements of an eventual success, the commercial uses of which are not as yet very clear, have gradually accumulated during the past half century.

"The present is, I believe, the third international conference on aerial navigation. The second took place in Paris in 1889, and a fourth is projected to take place in that city during the Exposition of 1900.

"The Conference of 1889 undoubtedly forwarded the solution of the problem, by making the public aware that a number of sane men were studying it in various parts of the world, by making these men acquainted with each other's labors, and by disseminating information concerning the scientific principles involved, the mechanical difficulties to be surmounted, and the practical details of aerial construction generally. Probably as a consequence of this very considerable advance has been made during the last four years, as will be indicated hereafter, and a number of promising proposals are now in progress of experiment and development.

"We may fairly expect similar results to follow from the present Conference. We may hope to collate here considerable knowledge concerning the scientific principles involved,

to gain information concerning the latest researches, and to establish some concert of action.

"Success, when it comes, is likely to be reached through a process of gradual evolution and improvement, and the most that we can hope to accomplish at present is to gain such knowledge of the general elements of the problem as to enable us to judge of the probable value of future proposals, both as mechanical or as commercial enterprises.

"More important still, we may perhaps help to enlighten a number of worthy but ill-equipped inventors who are re-trying old experiments, with no proper understanding of the enormous mechanical difficulties involved."

Referring to the prospect for dirigible balloons, he continued:

"The conditions as to resistance, lifting power, propellers and motors are now pretty well known, the speeds can be calculated with approximate accuracy, and while improvement can doubtless be achieved in the energy of the motor, in the efficiency of the screw, and especially in the form of the navigable balloon to diminish the resistance, it may be affirmed with confidence that railway express-train speeds cannot be attained with balloons of practicable dimensions. They may be used for war purposes or for exploration, but while we may say that the balloon problem is approximately solved, we may also say that the solution does not promise to become a commercial success, or to yield a large money reward to inventors."

With reference to aviation, he said:

"It is a mistake to suppose that the problem of aviation is single problem. In point of fact it involves many problems, each to be separately solved, and these solutions to be then combined. These problems pertain to the motor, to the propelling instrument, to the form, extent, texture and construction of the sustaining surfaces, to the maintenance of the equipoise, to the methods of getting under way, of steering the apparatus in the air, and of alighting safely. They each constitute one problem involving one or more solutions, to be subsequently combined, and these are the elements of success already alluded to as having gradually accumulated, which I propose to pass in review, more particularly to appreciate what has been accomplished since 1889."

Having noticed each of these problems in turn, he concluded:

"I hope you will agree with me that some of the elements of success have gradually been accumulating, and that there has been real, substantial advance within the last five years. There is still much to be done, but a number of experimenters have each been working on one or more of the problems involved, and they have made it more easy for others to forward the solution still farther.

"From this brief review of recent progress it would appear less unreasonable than it seemed a few years ago to hope for eventual success in navigating the air, and it may now be reasonably prudent to experiment upon a small scale, particularly if the inventor does so at his own expense; for the chances of commercial success seem still too distant to invite others to engage in the actual building of a flying machine, unless they do it with the understanding that they may lose their money. This is the course which has thus far been followed by the three or four experimenters who now seem in the lead, and it may not be long before they achieve such success as fairly to warrant them in proceeding to the construction of a full-sized machine.

"In any event, without concerning ourselves with the possible commercial use of such apparatus, we may hope here to advance knowledge upon this interesting problem, and to be of service to those ingenious men who are seeking for its mechanical solution."

The presiding chairmen of the meetings were: on the first day, Mr. Chanute; on the second, Dr. Thurston, of Cornell University; on the third day, Colonel King, of the U. S. Army. The papers contributed were mostly presented in very brief abstract, being entirely too long and too numerous for a full reading.

At the conclusion of the third meeting Mr. Chanute, wishing to inaugurate a practical application of the knowledge thus far accumulated, volunteered to be one of 20 persons to subscribe each $1,000 to an experimental fund, for the purpose of trying such scientific experiments, to be approved by a board of experts, as might be deemed likely to result in eventually accomplishing mechanical flight.

On motion of the secretary a fourth meeting was arranged for the following day, in which no papers were read, but the many topics already presented were further discussed. In this meeting Mr. D. Torrey, of Detroit, presented a plan for furthering Mr. Chanute's proposition, and Mr. C. D. Mosher, the builder of the fast yacht *Norwood*, informed the meeting of his achievements with light, powerful steam-engines, and of their probable value for aeronautical purposes.

An encouraging feature of the congress was that great interest in the success of its meetings and in the publication of its proceedings was manifested by prominent and capable engineers and scientists. Letters of cordial interest or contributions to the papers were received from the British Aeronautical Society, the Aerial Navigation Society of France, the Aviation Society of Munich, the Imperial Aeronautical Society of Russia, and the Aviation Society of Vienna. It is probable that the success of this Conference will lead to the formation of an American aerial navigation society, and also it is to be hoped to substantial and well-directed attempts of a practical nature.

AMERICAN AND ENGLISH LOCOMOTIVES.

(*Continued from page 374.*)

Our engravings this month represent the smoke-boxes, steam and exhaust-pipes, and spark-arresting devices of the two engines which have been the subjects of this series of articles.

The specifications for these parts for the English engine are as follows:

SMOKE-BOX TUBE-PLATE.

The smoke box tube-plate is to be ⅝ in. thick, the tops and sides of the plate being turned forward 2¼ in., forming a flange for the smoke-box, and is to be secured to the boiler barrel by a continuous weldless ring of angle steel well annealed, and supplied by makers to be approved by the Railway Company's Locomotive Superintendent. The ring must be faced, bored, and turned on the edges, and then shrunk on the boiler barrel, and is to be double riveted to the same, the rivets being placed zigzag. The tube-plate is to be faced where it is joined to the boiler steel angle. Eight wash-out plugs are to be inserted in the plate, as shown on the drawing.

SMOKE-BOX.

The smoke-box is to be of the form and dimensions shown on drawing. The sides and crown are to be $\frac{5}{16}$ in. thick, riveted to the flange of the smoke-box tube-plate. The front plate is to be in one and ⅝ in. thick. An angle-iron 2½ in. by 2½ in. by ½ in. thick is to be riveted to the front and side-plates. A hole for the door is to be cut in the front plate 3 ft. 10 in. diameter. The door is to be of Best Staffordshire iron ⅝ in. thick, protected on the inside with a shield, placed 1⅝ in. from door. Great care must be taken that the door when closed is made a perfectly air-tight joint. The cross-bar is to be made to lift out of forged brackets, which are to be riveted to the inside of the front of the smoke-box. Two handles and a gripping screw are to be provided. All the plates are to be clean and smooth and well ground over. All rivets are to be ⅝ in. diameter, pitched as shown on drawing, and are to be countersunk and filed off flush. The outside handles are to be finished bright. All lamp iron brackets are to be fixed as shown.

CHIMNEY.

The barrel of the chimney is to be of good smooth Best Best Staffordshire iron ¼ in. thick, to have a butt joint, and is to be riveted together with countersunk rivets down the back, having a hoop of half round iron at the top; the bottom is to be of Best Yorkshire iron or mild steel plate ⅜ in. thick, perfectly free from hammer marks, and accurately fitted to the smoke-box. The height of the top of the chimney from rails is to be 13 ft. 2¾ in.

STEAM-PIPES.

The steam-pipes in the smoke-box are to be of copper No. 6 Standard W. G., and 4 in. inside diameter, to have gun-metal flanges at both ends properly brazed to the pipes and accurately faced so as to secure steam-tight joints. Each steam-pipe is to be led to the cylinder, and is to be secured to the same with studs and brass cover-ended nuts.

VORTEX BLAST-PIPE.

The blast-pipe to be Adam's patent vortex, of the form and dimensions shown in the drawing, with an annular exhaust. The blast-pipe is to be secured to the cylinder with studs and brass cover-ended nuts.

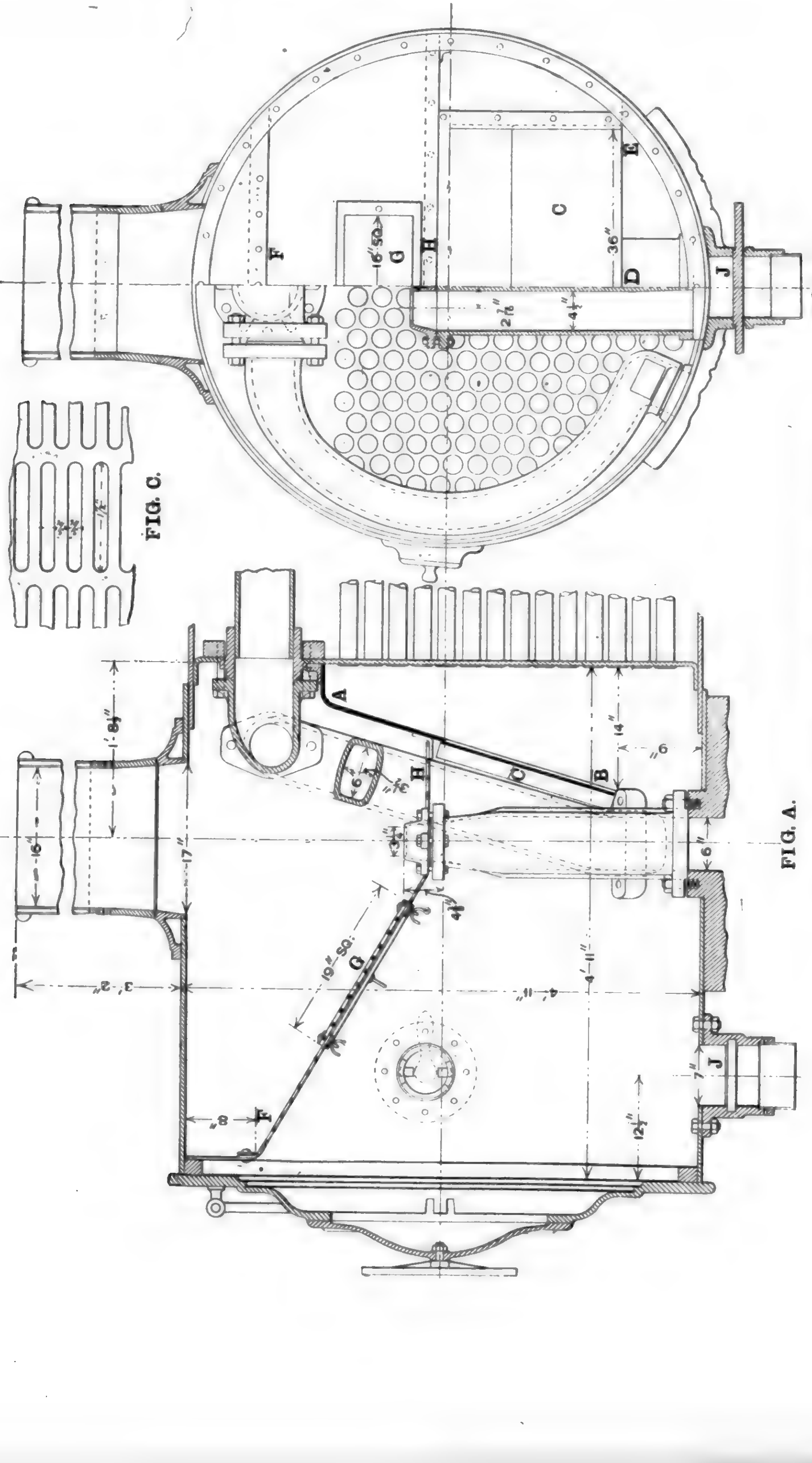


FIG. A. FIG. B. FIG. C.

SMOKE BOX FOR AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

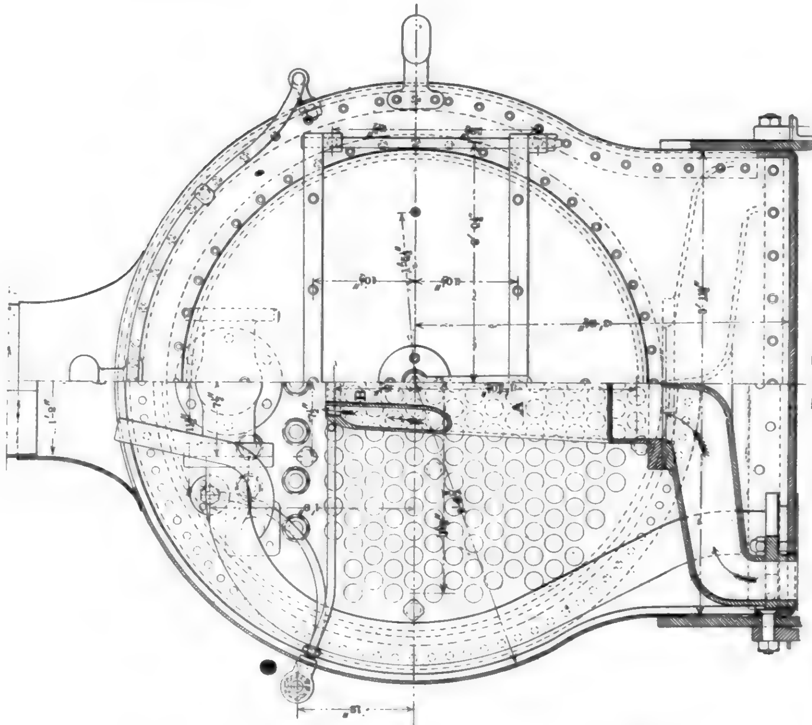


FIG. E.

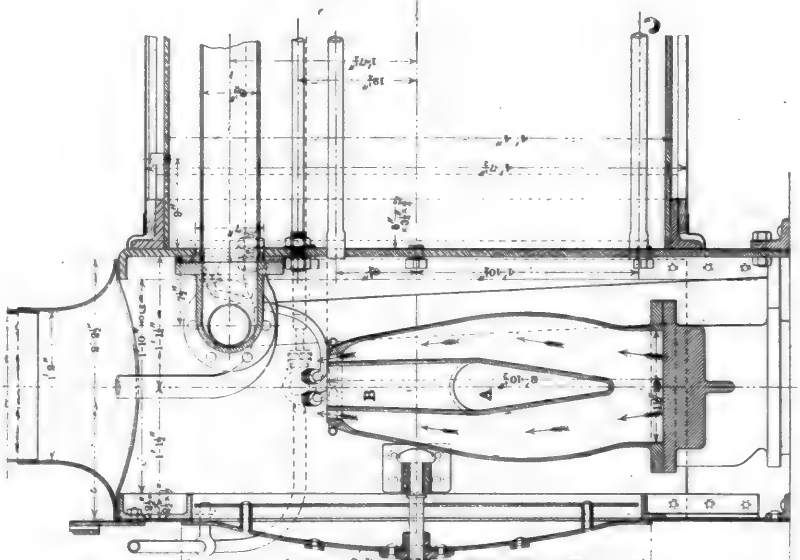


FIG. D

SMOKE-BOX FOR ENGLISH EXPRESS PASSENGER LOCOMOTIVE.

The specifications for the American smoke-box are briefly as follows:

STACK.

Smoke-stack straight, deflecting plate and netting in smoke-box.

From our engravings it will be seen that the differences in construction in the parts therein illustrated are greater than in any other portions of the two engines. The American engine for the New York Central & Hudson River Railroad has the cylindrical form of extended smoke-box now so generally used in this country, with deflecting and perforated plates to arrest sparks, while the English engine has no arrangements of this kind.

In fig. A, which represents a longitudinal section of the American smoke-box, *A B* is a solid deflecting plate in front of the tubes, and extending downward to the line *D E*, fig. B. *C* is a sliding-door which gives access to the tubes. *F G H* is a perforated plate, the form of the openings in which are shown in a larger scale in fig. C. *J* is a "cinder pocket," as it is called, for the removal of cinders from the front end of the smoke-box, and has a sliding-door by which it can be opened and closed. *G* is a removable section of the perforated plate, arranged to give access to the space above *F G H*. The exhaust pipes and blast nozzles are double, as shown. The steam-pipes are cast iron, whereas those of the English engine are copper. The other parts in the American smoke-box require no description.

The English smoke-box, it will be seen, is not extended further forward than is required to give room for the steam and exhaust pipes and the chimney, and, as already pointed out, has not deflecting plates or other devices for arresting sparks. The rectangular form of the bottom of the smoke-box and the method of fastening the cylinders to it is lighter than the corresponding parts on the American engine, but they are also more expensive to make. This form of smoke-box was very generally used in this country 25 years ago. Rogers, Winans and Hinkley's engines were all made in this way. The cylindrical smoke-box was used by William Mason as early as 1855 or 1856. He attached a separate cast-iron saddle to the smoke-box, and then bolted his cylinders to it. Later cylinders were made with one-half of the saddle cast on each one, and united in the center of the engine. This method is now almost universally employed here in preference to the rectangular plate iron smoke-box, with cylinders attached to it. It is thought that the cylindrical smoke-box, with cylinders having half saddles cast on them, makes a much cheaper and stronger job than the old-fashioned plan, and it would be difficult now to induce any of our locomotive builders to go back to the old plan, which is still in general use in England. Of course the use of plate frames has had more or less influence in leading English engineers to adhere to the rectangular form of smoke-box, as it would not be easy to adapt our plan of half-cylinder saddles to plate frames, which fact shows how interdependent one part of the design of a locomotive is on another.

It of course is not possible to establish without any question which method of construction is best—the cylindrical or the rectangular form of smoke-box. It may be said, though, that the opinions of *all* locomotive builders, superintendents, and master mechanics in this country are unanimous in favor of the cylindrical form and the half-saddle plan.

The engraving of the English smoke-box shows the vortex blast-pipe, which is an invention of Mr. Adams of the London & Southwestern Railway. A little explanation of its construction may, perhaps, not be out of place here.

As shown in the longitudinal plan, fig. D, the exhaust pipe is of bifurcated form, with an annular opening at the top. Its general shape is not unlike a pair of trousers, the two legs being united at their lower ends. Between the two legs is an opening *A*, extending upward to *B* inside of the annular blast nozzle at the top. The air and smoke is therefore drawn or forced upward not only by contact with the outside surface of the current of escaping steam, but also by the inside surface of what is a cylindrical shaped column of steam as it escapes from the blast orifice.

To what extent this device is used on other English roads besides the London & Southwestern we are not able to say, but we have received such favorable reports of its performance on that line, that we think American locomotive superintendents should recognize its merits or at least give it a trial. It should be added that it is patented in this country, but doubtless favorable arrangements can be made with the inventor for its use by those disposed to try it.

(TO BE CONTINUED.)

THE BORK CONSTRUCTION OF LOCOMOTIVE BOILER.*

It is a remarkable fact that the locomotive boilers built for the first railroads have been retained unchanged as the type for later constructions, in spite of the great disadvantages resulting from the arrangement of the fire-box, and which have been recognized from the beginning. The large number of stay-bolts and braces which are required, the universal use of flat surfaces for the sides of the fire-box, against which the steam pressure acts, the great cost of construction, its favorable arrangement for the deposition of scale and the difficulties which it presents for the removal of the same, should all militate against it. Then the thicker the layer of scale that is found, the greater is the loss of evaporative efficiency of the boiler.

Moreover, as copper has, up to the present time, been principally used in Europe for the construction of the fire-box, and that, too, at a great expense, it has been found that the renewal and maintenance of the same costs from 20 per cent. to 25 per cent. of the total expense of all repairs.

Thus the renewal and maintenance of the fire-box, besides adding a very considerable amount to the repair account, also serve to keep the locomotive for a considerable length of time out of service. Besides this, even with the most scrupulous care, the fire-box must always be considered as the most dangerous part of the locomotive, and it is well known that the great majority of locomotive boiler explosions take place either in the fire-box itself or the outer shell of the same.

If, then, in spite of this well-known defect, no radical change has thus far been recognized, it is natural to seek for the reason in the circumstances of the case, which may rest upon the universal opinion that a sufficient supply of steam can in no way be so well obtained as in the locomotive type of boiler, where the combustion takes place in an enclosed fire-box, and a portion of the heat developed is radiated directly against the sheets wet by the water in the boiler. This supposition, as well as the other conventional method of viewing the matter—namely, that the efficiency of a locomotive is in a general way proportional to its heating surface—was shown in 1870 to be without foundation, and this was confirmed by experiments made with brick-lined locomotive fire-boxes on the Hungarian State Railways, formerly the Thuringian Railway, and on the Swedish State Railways; but these experiments did not give perfectly conclusive results.

On a suggestion which I made before the Society of Railway Science, in 1890, a locomotive, No. 834, with a brick-lined fire-box has been built at the Tempelhof Works, and has been submitted to very careful experiments this year. From the results obtained, the opinion which has been held regarding the standard form of fire-box must be recognized as being entirely untenable.

It must now be acknowledged that the attainable efficiency of the locomotive is at least as high with the brick-lined fire-box as with any boiler of the ordinary form that has thus far been constructed. Furthermore, it has been shown, in regard to the opinion that the efficiency of a locomotive is proportional to the heating surface, that it is at fault. This efficiency is dependent, as further experiments have shown, on the intensity of the heat produced. The heating surface, therefore, only enters into the consideration of the case to the extent that it must be sufficient to cool the gases of combustion, so that these latter do not enter the smoke-box at a temperature above 575° F.

Construction of the New Boiler.—The new construction of locomotive boiler, which was built for freight engine No. 834, is clearly shown by our engravings. Instead of the ordinary fire box there is an extension from the upper portion of the shell, which is retained in its usual form, leaving the outer shell of the fire-box without further modification, while the back end of the shell terminates in a sort of water tube, and instead of the ordinary fire-box there is one built up of and lined with fire-brick, so as to form a space similar to that of the original fire-box. For cases where the shell is proportionally short, it is best to lengthen the same somewhat at the back; and it has been found by experiment that this length will be sufficient in all cases where a length of tubes of 4 meters (13 ft. 1½ in.) is obtained. Engine No. 834 has a rather high outer fire-box shell, so that the space above the arch of the fire-box proper is somewhat unnecessarily high, but in the regular construction of freight engines, where the boilers are new throughout, the space over the fire-box will be made smaller.

The closed cylinder *S* is attached to the back tube-sheet and extends over the whole length of the fire-box projecting out

* *Glaser's Annalen für Gewerbe und Bauwesen.*

through the back plate. In the attachment of the forward end of this cylinder, by means of the flanging, the original number of tubes is not materially lessened. It should be noted that in converting boilers of the present construction into those having the brick fire-boxes, it is not necessary to increase the heating surface of the tubes by an amount equal to that of the fire-box which is removed. It is possible to work with a considerably smaller heating surface without in any way diminishing the original efficiency of the boiler, as the experiments, which will be detailed later, have shown. In the case under consideration the reconstructed boiler had a total heating surface of only 1,141 sq. ft., while that of the original boiler was 1,335 sq. ft.

The cylinder *S* offers, as shown by fig. 2, a suitable support for both sides of the brick crown. At the outsides the arch of the crown has a footing on the top of the side walls. In order to obtain the most perfect combustion possible, there is a brick arch of proportional length, which extends over the forward half of the fire-box. On each side of the brick arch and close to the tube-sheet there are openings for sweeping out such accumulations of soot and unburned coal as may have collected upon it. It has also been demonstrated that such accumulations, both here and in the smoke-box, are exceedingly small.

In the construction of this fire-box a highly refractory material must be used, since the temperature stands at from 2,500° F. to 3,500° F. The ordinary so called Chamotte stone is not good enough for this work, and I have therefore used a fire-brick made out of a mixture of burned argillaceous schist and a platinum-bearing clay containing a little silicic acid, and where it is held in a combined form as perfectly as possible. According to results which have been obtained up to the present time, a fire box built up in this manner can be counted upon to give about 12,500 miles of service. As shown by the engravings, the side walls are built of ordinary blocks with a slight groove; these walls run out to the outer shell of the fire-box, while between the latter and the alternate courses there is an air space of from 1 in. to 2 in. Other than this, there is almost no anchorage between the sheet and the walls. It has been shown that this arrangement makes an extraordinarily solid fire-box, and one which is not at all disturbed by the very considerable shocks to which it has been subjected, and one which is also guaranteed to be very effective against jets of hot water. The side walls as well as those at the front and back are attached to the outer shell by a channel iron ring. The opening for the fire-door is made in the back sheet by an angle iron ring to which a wrought iron ring is riveted. A similar and somewhat cone-shaped frame carries the fire-door, and is itself filled with a protective fire-brick.

As for the grates, which have an area, as given later on, of 16 sq. ft., it may be mentioned that they are of the rocking type, so arranged that the front end of one-half can be raised and lowered about 1¼ in. Thus, as shown in fig. 4, of the two grate-bars *E* and *C*, one is rigid and the second is fastened to the oscillating shaft *D*. This latter supports the movable bars, which can be easily moved up or down from the foot-plate by means of the levers *H* and *K*. In ordinary running the movable bars are kept flush with the rigid bars, as indicated by *Z*, fig. 2.

It will be readily understood that the formation of steam on the tube-sheet would be very great, and that in consequence thereof there would be a strong current of water flowing against it, hence it becomes necessary to take some precautions in order to prevent the formation of scale. For this purpose the plate *A B*, shown in figs. 1, 2 and 3, is used. This is fastened to the sheets of the shell by means of angle irons, and is bored with holes for the admission of the tubes. In this space, enclosed between the plate and the tube-sheet, there exists, in consequence of the temperature, which is considerably higher than in other portions of the water space, a rapid upward current, so that on the interior there is always a fresh stream of water flowing against the hot surfaces of the tube sheets and the back ends of the tubes; and, on the other hand, the finely divided particles of scale are carried up by the current and prevented from settling near the tube-sheet. It should be noted that the prevention of scale formation and the production of a rapid circulation is of especial service, as experience has shown in connection with the brick lined fire-boxes built by me for locomotive boilers between the years 1879 and 1886, for unless this is done the life of the tube-sheet will be very short. I am aware that a similar experience has obtained on the Hungarian State Railway, where it has also been shown that the life of the tubes will be shortened as well.

The results of practice, which have been obtained with the boiler built on the lines just enunciated, have shown a perfect freedom from the foregoing defects. It is, therefore, safe to say that the life of the tubes will henceforth be no shorter than in the ordinary type of locomotive, because even unskilful firing and a partial baring of the grates, admitting a great quantity of air, cannot cause a rapid or material cooling of the tube-sheet, since in the higher temperature of the sides of the fire-box there is an ample reservoir of heat to warm all the air by contact before it reaches the tubes. In order to give the products of combustion full opportunity to communicate their heat to the tubes on their way to the smoke-box, a deflector-plate *M N* is placed in the latter. This is pivoted at its upper edge *N*, and, when it is necessary to clean the tubes, can be easily turned up out of the way. Measurements in the smoke-box have shown that the temperature of the gases leaving the tubes is about the same at all points. This construction, which has such a wide application on American locomotives, can therefore be regarded as a very effective arrangement.

The cost of this new construction, if applied to a boiler previously built, is very considerably less than for a new fire-box of the ordinary construction. The latest figures show that 4,500 marks (about $1,125) was received for old material, while the new fire-box cost only 3,100 marks (about $775). For building an entirely new boiler with the brick fire-box having a capacity sufficient for the standard freight engine, the expense would be about 6,000 marks ($1,500), while the cost of a boiler of similar efficiency of ordinary construction would be about 11,000 marks ($2,750).

Working of Locomotive No. 834 with the Brick-lined Fire-Box.—First of all, a number of trials were made in order to obtain the necessary information regarding the handling of the fire. It appeared that this differed from that giving the best results with the ordinary fire box, in that it was unnecessary to maintain so deep a fire, since the grate area was proportionately smaller. In spite of this there was a very slight production of carbonic oxide, which, as is well known, causes a very marked lowering of the effectiveness of the fire.

A difficulty arose in the progress of these experiments in that the material originally used for the construction of the walls was found to be deficient in refractory powers. In consequence of this a molten clinker ran down from the crown and the arch, which clogged the grates, especially near the tube-sheet and the side walls. This difficulty has been removed, as I have already said, by the use of highly refractory materials.

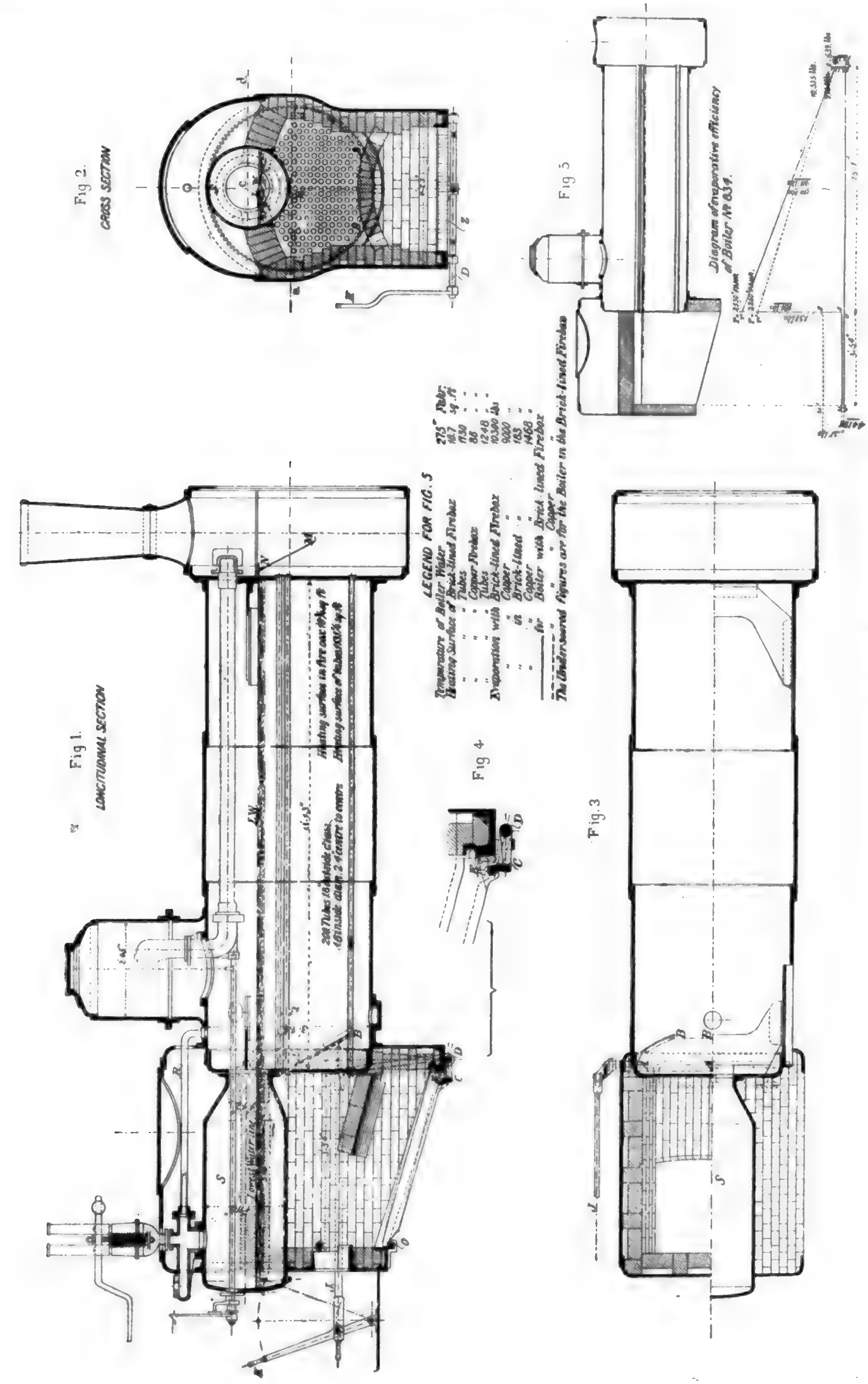
Then, in order to have a basis of comparison for efficiency, the engine was put upon a systematically laid out freight run of 80 miles on the line from Tempelhof to Bitterfeld, and on one of 73 miles from Tempelhof to Elsterwerda, working in both directions. Likewise trains were dispatched under the most disadvantageous conditions of the weather, when the work must be done in the teeth of a storm or in a fall of snow.

The weight of trains was therefore very frequently no greater than that given to the ordinary locomotives equipped with the original form of fire-box. The evaporation was so free on the heaviest upgrade, which was about 1 in 200, that with the normal load on this grade a speed of from 18¾ miles to 22 miles per hour was maintained with a draft that rarely exceeded 2 in. in the water column.

In order to obtain the most reliable averages possible in our investigations as to the merits of the new boiler, a large number of trains loaded with perishable goods were hauled. The average efficiency was obtained by measuring the draft of the train by a Holtz apparatus fastened to the back end of the tender. The speed between stations was obtained by noting the total time, deducting two minutes for starting and stopping, and also by means of a speed recorder.

Furthermore, the evaporation at different speeds, as well as the vacuum in the smoke-box, was very carefully observed at different speeds. Water measurements were taken at every stop, and the waste water which was used for wetting down the coal, injecting into the smoke-box, and for other purposes was deducted. The evaporation obtained in this way is therefore only an approximation of the water evaporated. As close observation showed that comparatively high water was a rarity, it is evident that comparatively little was entrained, and that the results obtained were very close to the water actually evaporated.

It was also of great interest to obtain the most accurate data possible regarding the temperature of the products of combustion as they entered the smoke-box. It was found, by trying a great many different methods of measurement, that a quicksilver thermometer with its bulb in the center of the smoke-box gave the best results. Then by having a means of adjusting, the temperature at the upper as well as the lower row of tubes could be obtained. After the deflector-plate had been adjusted only a slight variation was to be observed, so that the temperature as measured at the center of the tube-sheet may be taken as an average of the whole. The measurement of the temperature of the gases of combustion in the fire-box



THE BORK LOCOMOTIVE BOILER WITH BRICK-LINED FIRE-BOX.

was made at the back end of the fire-box above the brick arch by means of a metallic pyrometer.

In order to insure the perfect combustion of the fuel and the complete convection of the heat produced, a large number of analyses of the gases as they entered the smoke-box were made. These analyses were made by means of the Orsat apparatus, and by taking the averages of a large number of examinations the amount of carbonic oxide and carbon dioxide was obtained. Samples were taken when the fire was burning normally with the fire-door closed.

In order to obtain the amount of convection to the fire-box casing, the temperature of this latter was obtained by a large number of observations made on the side walls as well as at the front and back. The thermometer was put in through the jacketing until the bulb was in contact with the plate. In like manner the temperature of the outer shell of the fire-box of the ordinary engines was obtained.

Experimental Investigations and the Results Derived Therefrom.—The efficiency of the locomotive, after the new design of boiler was placed upon it, was at least equal to that which it had originally. The machine was therefore not only up to the limit of its efficiency, but was capable of still further increase of work, in spite of the fact that the original boiler had 194 sq. ft. or about 17 per cent. more heating surface.

At a speed of from 15 to 19 miles per hour, with the steam cutting off in the cylinder at from one-third to one-quarter stroke, and a vacuum in the smoke-box of 2 in. of water column, the engine with the new construction developed about 450 H.P., while previously under exactly similar circumstances it had not been able, as a general rule, to develop more than 420 H.P. The number of loaded axles hauled could therefore be somewhat increased, as was shown by the tabulated results obtained by the maintenance of the normal steam pressure, the height of water in the boiler being held without any difficulty. The coal consumption was generally 10 to 25 per cent. less, as shown by the premium awards.

Now, from what has been just stated, and which has been established by carefully observed performances—namely, that the engine with the brick-lined fire-box has not only fully reached the original efficiency which it had, but has even exceeded it somewhat, so it is therefore especially important to establish by numerous experiments that the absorption of heat with the new construction is at least fully as perfect as that with boilers heretofore constructed with a copper fire-box. In order to have a definite understanding of the matter, it is necessary that we should take into consideration the course of events as they occur in the transference of the heat to the water of the boiler, and to determine how many heat units can be thus transferred to the water by the burning of 1 lb. of coal. The events as they occurred in the brick-lined fire-box are, that the total amount of heat developed passes into the products of combustion. If we deduct therefrom the very slight amount of heat which passes direct into the boiler, the heat contained in the products of combustion will then, for the most part, be transferred into the water of the boiler surrounding the tubes as the gases stream through these latter. The loss of the heat, which the gases still contained when they enter the smoke-box, is a matter of the utmost importance. It is carried out through the stack and serves to lower the evaporative efficiency. It is evident that this loss increases with the temperature of the gases in the smoke-box, and also increases with the quantity of air which must be brought into the fire-box in order to burn a pound of coal. Furthermore, observations must be made as to the loss of heat which occurs by convection and radiation through the walls of the fire-box. All other loss, such as radiation through the grates, loss of heat in the ashes, etc., can be considered to be the same in the new boiler as in the earlier ones, and should not be made the subject of observation, since the circumstances are the same and of equal magnitude in both cases. It is evident that in a comparison between the two types of boilers relatively to their efficiency as heat-absorbers, they must be the same if the temperature of the gases entering the smoke-boxes shall be the same, and if, furthermore, the radiation through the enclosing shells of the fire-box shall be the same, and finally, if the same quantity of air is used in burning the same quantity of coal.

If combustion is to be perfect, then the least possible amount of air must be admitted, the whole of the coal must be burned into carbonic acid, and no carbonic oxide must be developed.

By reference to the relative chemical equivalents, we find, therefore, that for 1 lb. of coal it is necessary to supply 2.67 lbs. of oxygen and 8.94 lbs. of nitrogen, so that the gases resulting from the perfect combustion of 1 lb. of coal is $1 + 2.67 = 3.67$ lbs. of CO_2 of carbonic acid and 8.94 lbs. of nitrogen, making a total of 12.6 lbs. In this case then 11.6 lbs. of air must be admitted in order to burn 1 lb. of coal. The volume of the gases resulting from this combustion will equal about 38 cub. ft. of carbonic acid gas CO_2 and 146 cub. ft. of nitrogen. Practically it is not possible to admit such a small quantity of air and cause all of the oxygen contained therein to be converted into carbonic acid gas. There must be many times the necessary quantity of air admitted if the formation of carbonic oxide is to be entirely avoided.

From the analyses of the gases of combustion taken from the locomotive with the brick-lined fire-box, it was shown that in the smoke-box, when the engine was working in its regular way, gases of combustion contained 12 per cent. of CO_2, 6 per cent. oxygen, and 82 per cent. nitrogen. It therefore appears that carbonic oxide was not present, and that the gases of combustion which resulted from the burning of 2.2 lbs. of coal contained 38 cub. ft. of carbonic oxide, 19 cub. ft. of oxygen, and 280 cub. ft. of nitrogen. The weight of this volume of gases was 3.67 lbs. of carbonic acid, 1.82 lbs. of oxygen, 15.4 lbs. of nitrogen, making a total of 20.9 lbs. of gas of combustion. Hence there was admitted $20.9 - 1 = 19.9$ lbs. of air, or $19.9 - 11.6 = 8.3$ lbs., or 71 per cent. more than the minimum volume which is absolutely necessary for complete combustion. In this weight of gas of 20.9 lbs. the total heat developed by 1 lb. of coal is contained. Hence, the heat effect produced by the use of this coal was 12,625 heat units per pound. Since the temperature of the gases in the smoke-box under average conditions was 525° F., it is evident that the loss of heat which passes out through the stack with the gases, and which cannot be made available for evaporative purposes is equal to $20.9 \times 525 \times .23 = 2{,}524$ heat units, or taking a percentage of the total heat developed of 12,625 heat units, we have a loss in round numbers of about 20 per cent. Therefore from the combustion of 1 lb. of coal we have $12{,}625 - 2{,}524 = 10{,}101$ heat units, which was transferred to the water of the boiler. Equalizing this with the heat absorptions in boilers with the ordinary fire-box we come to the next result. A series of analyses, made with the standard freight locomotive, showed that when the combustion of the fuel was perfect the volume of the gases averaged about 9 per cent. carbonic acid, 8.5 per cent oxygen and 82.5 per cent. nitrogen, making a calculation similar to the one just given: we find that the gases resulting from the combustion of 1 lb. of coal consists of 3.67 lbs. of carbonic acid, 2.5 lbs. of oxygen and 21.5 lbs. of nitrogen, giving a total weight of 27.6 lbs., so that it is evident that 26.6 lbs. of air was admitted for each pound of coal. It seems from this, then, that, with the ordinary type of locomotive fire-box, in order that a perfect combustion may be obtained, a considerably greater excess of air must be admitted than the minimum, which is absolutely necessary, and the excess per pound of coal is equal to $26.6 - 11.6 = 15$ lbs., or 2.3 times the weight of air absolutely required. On the other hand, the new construction only needs $26.6 - 19.9 = 6.7$ lbs. of air more than is absolutely used.

In consequence of this great excess of air there is a considerably greater loss with the escaping gases than occurs with the brick-lined fire-box, since the temperature of these gases is not materially lower than in the brick-lined box. Furthermore, investigations with the standard freight engines have shown that the smoke-box temperature is practically the same as in that of the boiler with the brick-lined fire-box. The observations show a variation between 500° F. and 575° F., so that it would not be far out of the way if we should say that an average of the whole was at 525° F. Under these circumstances the loss of heat with the ordinary fire-box can be calculated to be about $27.6 \times 525 \times .23 = 3{,}333$ heat units, or in round numbers about 26 per cent. of the heat developed by 1 lb. of coal. Therefore for this method of combustion 1 lb. of coal would give up only $12{,}625 - 3{,}333 = 9{,}292$ heat units to the water of the boiler, while the absorption with the brick-lined fire-box under the same conditions would be 10,101 heat units. Therefore the boiler with the brick-lined box shows a saving of about 8 per cent. of the heat developed over that of the ordinary fire-box.

It may appear questionable, however, whether this improvement in the absorbing qualities may not be lessened by the radiation of heat through the walls of the fire-box. In order to obtain definite information in regard to this subject, similar temperature measurements were made with the boiler having the new fire-box and a boiler with a copper fire-box. The following are the results obtained from this examination:

Ordinary Locomotive No. 525.	New Locomotive No. 624.
Side sheet, 206° F.	Side walls, 199° F.
Back sheet, 156° F.	Back walls, 194° F.
Front sheet, 156° F.	Front wall, 203° F.

Outside air, 50° F.

From the slight difference in these figures it will be seen that there will be relatively a very slight difference in the loss of heat. It may be assumed that the radiation of an iron sheet into the surrounding atmosphere per square foot per hour for 1° difference in temperature will be about 2.86 heat units.

Hence, taking the measurements of the two fire boxes into consideration, it will be found that the brick-lined box will radiate about 1,700 heat units per hour more than that with the ordinary construction. This loss will be supplied by the consumption of about .18 lb. of coal per hour, and therefore is of so slight a value as to deserve no consideration whatever.

It is also evident that there will be a loss of heat in proportion to the weight, which is absorbed in heating the brick work of the fire-box up to the working temperature; but it must also be remembered that this heat was formerly wasted to a great extent, and in this case it is given back to the water of the boiler when the engine is standing still. But this has relatively no importance in the necessary heat production during the daily work. The temperature on the fire side of the brick wall will be about 2,550° F., while on the other side it will be about 400° F., so that we may consider that the brick work has an average temperature of 1,475° F. The total weight of the brick work may be placed at 2,200 lbs., and taking the specific heat of the stone at .2, the total heat contained in the brick work will be about 2,200 × 1,475 × .2 = 649,000 heat units, which is equivalent to a combustion of a trifle more than 50 lbs. of coal. This insignificant consumption need not be taken into consideration, as it is well known that, for heating up the ordinary locomotive boiler, there is required on an average about 300 lbs. of coal.

From the foregoing data a twofold conclusion can be drawn —namely, that with an equal consumption of coal the boiler with the new fire-box has a somewhat higher efficiency in its absorption of heat and a greater evaporative efficiency, in spite of the fact that it has a smaller heating surface than the ordinary type of boiler.

It is of interest, therefore, to obtain a clear idea of the evaporative efficiency of the heating surface in the boilers with the new fire box, on the basis of the results obtained, and then to put it in comparison with that of the ordinary type of boiler.

The evaporative efficiency of the heating surface per unit of time is dependent, on the one hand, on the size, and, on the other, on the difference in temperature which exists on the two sides of such surfaces. This difference of temperature has undoubtedly its highest value in the fire-box, and falls gradually down from that point to the smoke-box. On their entrance into the tubes the products of combustion have a temperature of about 2,550°, while on their exit into the smoke-box under normal conditions of working, the temperature is not above 525°. The water in the boiler is under a pressure of about 150 lbs. to the square inch, and has a temperature of approximately 342° F. The differences, therefore, in temperature are 2,550 − 342 = 2,208 at the fire-box end of the tubes, while it is only 525 − 342 = 183° F. at the smoke-box end. The total evaporation per hour has a normal efficiency with a vacuum of 2 in. of the water column of 10,518 lbs. One square foot of heating surface therefore corresponds to an average evaporation of $\frac{10,518 \text{ lbs.}}{1,141 \text{ sq. ft.}} = 9.21$ lbs. per hour.

If we investigate the amount of heat taken up by the tubes and indicate the evaporation in the fire-box and on the smoke-box tube-sheet per hour, and indicate the efficiency of 1 sq. ft. of heating surface in these two points by x and y, we have the proportion $x : y = 2,208 : 212$. From this we may deduce the fact that, at the fire-box end, evaporation is equal to 1.67 lbs. per square foot. It may be taken for granted that the evaporation throughout the boiler per square foot of heating surface is very nearly the same as that of 1 sq. ft. of the heating surface of the tubes midway between the fire-box and the smoke-box. Out of the 10,518 lbs. of water evaporated, we have about 183 lbs. in round number evaporated in the fire-box, so that the 10,518 − 183 lbs. = 10,335 lbs., which must be evaporated throughout the length of the tubes. Taking the heating surface of the tubes into consideration, we find that we have an evaporation of about .89 lb. per hour.

Furthermore, there is a cooling which occurs throughout the boiler, so that the temperature of the gases which enter the tubes at 2,550 F. likewise falls away, so that we may consider the evaporation immediately at the fire-box end of the tubes to be 1.65 lbs., and at the smoke-box end as .14 lbs. per square foot per hour. If we take this evaporation as the ordinates at the end of the line $o\,p$ (fig. 5), whose length corresponds to that of the boiler, and connect the points q and r, then all points in the line $r\,q$ lie in ordinates representing the evaporation at different portions of the length of the tube along the boiler. If we divide the line $o\,p$ into 1,130 equal parts and erect ordinates at the points of division, then the surfaces which are included between the neighboring ordinates and the portions of the lines $o\,p$ and $r\,q$ will represent the evaporation per square foot per hour. The surface $o\,p\,q\,r$ has a total evaporative efficiency of 10,335 lbs. per hour. The evaporation of the boiler which extends over the brick portion over the fire-box in the brick-lined fire-box, will be represented by the rectangle $o\,v\,u\,s$ included by the abscissas and ordinates. The height $o\,s$ of this rectangle shows that the product of the figures denoting the area must be the same and give the same results of evaporation as in the ordinary fire-box. The surface $b\,o\,p\,q\,r\,s\,u$ then shows the evaporative efficiency of the total heating surface, as well as that which obtains in the different portions of the boiler. In like manner the surface $b\,o\,p\,q\,r^1\,s^1\,u^1$ gives the evaporation of the boiler with the original form of fire-box.

The heating surface in the fire-box was 86 sq. ft., and in the tubes 1,110 sq. ft. The evaporation in the fire-box per square foot per hour can be taken to be the same throughout its whole area, and evaporation then becomes 143.92 lbs.

The figures obtained from this calculation show the evaporative efficiency without any further trouble, and it can be readily seen that the boiler with the new fire-box, in spite of its smaller heating surface, can transfer an equal amount of heat to the water per unit of time, as the ordinary fire-box. These facts are clearly explained when we remember that with the brick-lined fire box the gases enter the tubes at a considerably higher temperature than they do where the ordinary fire-box is used, and evaporation per unit of heating surface is correspondingly increased.

The most important point, however, is that the smaller heating surface, in spite of the higher temperature of the entering gases, is so effective that the latter are cooled down to a point as low as they are with the ordinary construction.

The efficiency of a locomotive therefore should not be based, as heretofore, upon the heating surface, but rather upon the amount of heat which can be developed and absorbed in a unit of time. The amount of heating surface, therefore, should only enter into the consideration so far that it shall be sufficient to lower the temperature of the gases under normal conditions to 575° F. The further lowering of this limit of temperature by increasing the heating surface gives no real advantage in actual effectiveness. Suppose that the tubes of engine 834 were lengthened 15.7 in., whereby the heating surface would be increased about 10 per cent., then by the graphic method of representation which we have used, the increase of evaporation would only amount to about 77 lbs of water, or .75 per cent. of the total evaporation obtained. This increase of evaporation is a mere bagatelle when compared with the increased first cost and expense of maintenance with tubes having 107.6 sq. ft. less of heating surface.

Advantages of the New Type of Construction.—Aside from the improved steaming qualities, whereby a lower consumption of coal produced the same efficiency, there are two facts which seem to particularly warrant the introduction of this new type of boiler, to wit:

1. A very greatly reduced outlay in first cost, and
2. Possibility of an important increase of steam pressure, and therefore an increase of efficiency without a corresponding increase in the weight of the locomotive.

The author then goes on to make a careful comparison between the expense of construction and maintenance of the copper fire-box and the brick-lined fire-box of this new construction. As copper fire-boxes are unknown in American practice at the present time, these figures do not show what the relative expense would be between the brick-lined box and the steel box used in this country; but his conclusions, relative to the copper fire-box, are that there is a saving of maintenance of about 29 per cent.

The second important feature of the new fire-box—namely, that the steam pressure can be considerably higher than in that of the ordinary boiler, comes from the fact that the boiler being cylindrical in form, the only exception to perfect stability is at the points where the tubes enter and leave. In the ordinary fire-boxes which have thus far been made, the upper limit of pressure for locomotive boilers may be placed at 180 lbs. per square inch, and already at this pressure the maintenance of stay-bolts has been found to be very difficult, and accidents are no longer rare where the sheet has been stripped off the thread. With this new construction a pressure of 240 lbs. per square inch can be used without increasing the thickness of the metal heretofore employed, and it is within the possibilities of building a new boiler and using an increased thickness of metal that will readily sustain a pressure of 300 lbs. per square inch. But even with an elevation of pressure of from 150 lbs. to 240 lbs. per square inch there will be a very noticeable increase in efficiency, as will be seen by making a comparison of the work of these two pressures. Furthermore, the throwing of sparks is very much less with the brick-lined fire-box than with the fire-box of ordinary type, because the incandescent particles of coal will be completely burned before leaving the tubes, when they are subjected to the influence of the high temperature of the gases of combustion and the hot walls of the fire-box.

THE STEERING OF BALLOONS.*

By Rudolphe Soreau.

II.—ATTEMPTS AT STEERING.

I now beg to call your attention to a brief examination of those attempts at steering which merit attention, and in which I shall not seek to enter into details, but shall show in what way and to what extent the conditions laid down in the preceding section have been realized, following, as far as possible, the order given in the table.

General Meusnier.—The true progenitor of dirigable balloons is General Meusnier, of whom Monge has said: "He possesses the most extraordinary intelligence that I have ever come in contact with." In a series of papers, written in 1783, Meusnier laid down a project for a dirigable balloon, which did not receive in those troublous times the slightest approach to a practical application; it would, furthermore, have been difficult to construct this gigantic balloon, which was a sort of egg, with a capacity of 7,063,200 cub. ft.

There were three peculiarities characterizing this project. First, the propeller form of turning wings, which constituted a true helix, so that, according to the remark of Colonel Laussedat, Meusnier conceived the idea of using the helix for navigation long before Sauvage. Second, the ellipsoidal form of the balloon. Third, the presence inside the envelope of a pocket in which could be compressed the atmospheric air. This kind of natatorial vessel having for its object the realization of the ascensional and descensional movement without loss of ballast or gas. Meusnier counted on finding an aerial current flowing almost exactly in the direction which he desired to travel, and expected to pass to another current in order to correct the variation due to the first, and thus one after another to follow by a series of zigzags, the route over which he desired to pass. He did not attack the problem from the front; and the propeller, which was driven by men, was to play the rôle of an elevator and depressor.

Henri Giffard.—The first rational experiment was made about 50 years after the death of Meusnier. It was made by a man whose eulogy it is superfluous to pronounce, and whose mind, at the same time inventive and bold, was attracted by the grandeur of the problem.

The balloon which Henri Giffard constructed in 1852 (fig. 4), by the aid of Messrs. David and Sciama, Engineers of the School of Arts and Manufacturing, fulfilled the following conditions:

1. Thoroughly understanding the impotence of a propeller driven by men, Giffard resolved to use the steam-engine, then in its glory. The installation of a motor apparatus below a reservoir containing 92,290 cub. ft. of illuminating gas constituted a danger which did not deter him. He contented himself with placing the fire-box inside the boiler with a double envelope, and causing the gas to escape by a descending stack into which the steam escaped with all its expansive force as it left the cylinder; thanks to this energetic cause, the gases of combustion, already cooled in their passage through the envelope, were drawn into the stack, where the expansion of the steam lowered their temperature still further and killed all the sparks which they might contain, and threw them rapidly toward the back, so as to aid him in the movement of propulsion. The engine was a vertical cylinder machine; it already fulfilled in advance a portion of the progress of 10 years, from 1851 to 1861, which was brought about by this genius of an inventor in his steam-engines. Its power was 3 H.P. and its weight 330 lbs. with the empty boiler; the fuel and water doubled the weight. The shaft of the motor ran at the rate of 110 revolutions per minute, a three-armed screw 11 ft. 1.9 in. in diameter.

2. The balloon was spindle-shaped, with sharp points which certainly offered a more logical form than that of the ellipsoid. It measured 144 ft. 4 in. from point to point. The elongation —that is to say, the ratio of the length to the maximum height —was 3.6 to 1.

3. The net embraced almost the whole upper portion, even to the points; a little below the center the meshes expanded out into diamond shapes in order to make a better distribution of pressures on the envelope. These meshes formed the direct means of suspension of a long horizontal frame from which, at a distance of 65 ft. 7 in., the basket was suspended. The back end of the suspended portion served as a post for attaching the rudder. The valve at the top of the balloon could be opened by a cord, which passed through a shaft situated in the same vertical plane.

"I started alone from the Hippodrome," writes Giffard. "The wind blew with great violence. I did not dream, for an instant, of struggling directly against the wind; the strength of my engine would not have permitted it. That was acknowledged in advance and demonstrated by calculation, but I executed with great success different movements in a circle and with a lateral deviation. The action of the rudder quickly made itself felt, and scarcely had I pulled lightly on one of the two tiller ropes than I immediately saw the horizon turning about me. Nevertheless, as night approached I occupied myself with regaining the earth, and this I effected very fortunately in Elancourt, near Trapp."

After this happy experience Giffard sought to make a new step in advance. He constructed a balloon with a capacity of 112,995 cub. ft. and a length of 229 ft. 8 in., corresponding to an elongation of 7 to 1, which was practically about double the preceding one, and is shown in fig. 5. The beam was replaced by a wooden cross-piece placed along the upper meridian, the shape of which it followed, and does not seem to me to constitute any improvement over the original design. Finally, the motor and the rudder were subjected to important modifications. Yet Giffard did not see that the considerable elongation which he had adopted required special precautions. Thus, with the test which was made in 1855, accompanied by Mr. Gabriel Yon, in a wind with a velocity of 13 ft. per second, the results were less fortunate than the first; it lacked but very little in ending in a catastrophe. On rising the balloon turned about on itself, escaped from the net, and after a new ascension fell, cut into two pieces. The shock was produced by a sudden variation of the wind of several meters per second.

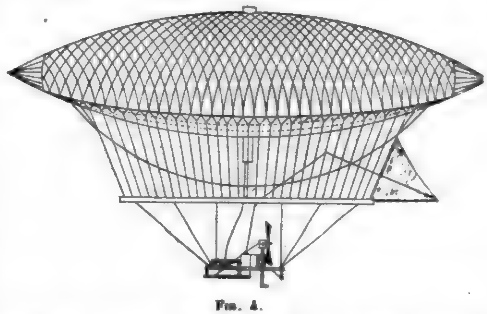


Fig. 4.

From what I have said regarding the conditions which a dirigable balloon must fulfil, it can be seen that the two great defects of the Giffard balloons were in not realizing them, either in permanence of form or rigidity of construction. Either one of these defects would have prevented success. As accessory defects, I will cite the following: Silk used in the inflated portion diminished to a great extent the advantages of the elongation from the standpoint of resistance; the consumption of water and fuel caused a continual lightening, which was not compensated for by the inevitable loss of gas; finally, the use of illuminating gas was not a fortunate one, and the difficulties of the problem are so great that no one should hesitate to inflate with hydrogen.

However that may be, Giffard, who counted on building the first aerial locomotive, will at least have had the glory of building and showing the first balloon which could be classified among the dirigable balloons. He conceived the ambitious project of a gigantic balloon of 1,765,773 cub. ft. capacity; the motor was to have had two boilers, one burning the gas of the balloon and the other petroleum. The million francs intended for this experiment were ready; the plans were prepared when Giffard, struck down by *cecité*, was compelled to give up work. Before dying the eminent engineer still desired to serve science by allowing it to profit by the great fortune which a life full of labor had given him.

Dupuy de Lome.—Giffard's works did not change public opinion, which continued, except on rare occasions, to consider the steering of balloons as a kind of Utopian dream. Such was the official opinion when on October 10, 1870, in the full session of the Academy of Science, a prominent man, Dupuy de Lome, affirmed, with considerable conviction, that he had taken upon himself to build a dirigable balloon and to establish thereby, in spite of the circle of iron which strangled Paris, the reciprocity of relations between France and its capital. Can we doubt the success of the engineer who made the first armor plate, and who passed in his own right as one

* *Mémoires de la Société des Ingénieurs Civils.*

of the illustrious men of the century? The credit of 40,000 francs was placed at his disposal, but the disorganization of industrial enterprises, the severity of the winter, the lack of resources, rendered the construction very slow, and the dirigable was ready only a few days before the capitulation. It was characterized by the following arrangements, as shown by fig. 6:

1. The propeller was a two-armed screw provided with a crab turned by eight men. It was 19 ft. 8 in. in diameter.

2. The balloon, which had a capacity of 127,137.6 cub. ft., had a form similar to that of Giffard's, but its elongation was only 2¼ to 1. Its length was 118 ft. 1.3 in.

3. The rigidity of construction was obtained very simply by attaching a point P of the car to the two points A and B of the balloon (fig. 7), so that the vertical $P\ V$ was always included inside, the angle $A\ P\ B$ when the system assumed an inclined position for any cause whatever. Under these conditions the weight of the car stretched the two chords, and the construction possessed the same rigidity as though it were formed of metallic bars, solidly riveting the connected points together. The exterior connection points $A\ P$, $B\ Q$ constituted the carrying net.

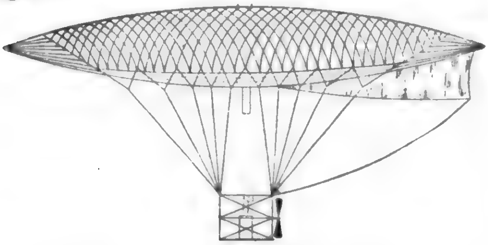


FIG. 5.

They start from a kind of gland or circle which follows the horizontal meridian. The interior suspension points $A\ Q$ and $B\ P$ form the balancing net; they are fastened to a second ring situated up at about one-quarter of the total height, and so as to be tangent to the balloon. The crossing point M had to be raised so as not to interfere with the aeronauts. The great engineer has shown the advantages of these two ties in a masterly manner, the combination of which bears the imprint of his balloon.

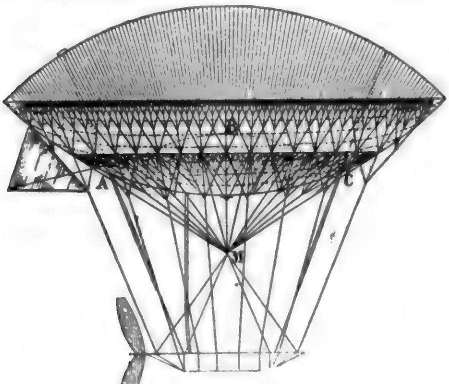


FIG. 6.

4. Dupuy de Lome, in reinventing the air balloon of Meusnier, whose memoirs were forgotten in the Archives of the School of Metz, divided the balloon into two compartments by means of a diaphragm, $A\ B\ C$, which was applied exactly to the lower part of the dirigable when it was completely inflated. To insure invariability of form, it was sufficient to inflate with ordinary air by means of a blower delivering into a pipe which connected the balloon with the car. If the air which was blown in was too great in quantity, it escaped by the safety-valve, located at the lower part of the balloon, before having acquired a pressure sufficient to drive out the hydrogen by the valves which are to be seen at the right and left of the balloon. It was to these valves that chords passed which served to manipulate the two hydrogen valves of the balloon. Simple calculations determined the dimensions which it was necessary to give to the balloon in order that the dirigable, after having reached a predetermined elevation, could be maintained completely inflated up to the time of its landing.

5. Finally, the resistance to advancement had been diminished by the substitution, for the net, of a housing of cloth to which the balancing chords were fastened, and by the adoption of a long car terminated by a prow and a poop covered with silk.

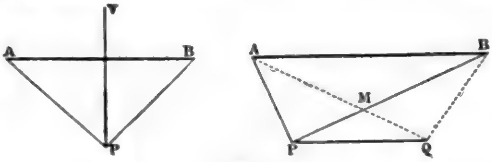


FIG. 7.

This balloon was very carefully designed from the standpoint of stability, but presents the capital defect of having a motive force absolutely insufficient to its needs. Dupuy de Lome understood this. "If it were possible," he writes, "to approach the dangers which an engine having a fire connected with it brings to the hydrogen-inflated balloon, it would be very easy to make an engine of 8 H. P. with the weight of seven men, which would very much diminish the weight of the equipage. The working motor would thus weigh about 490 lbs. The fuel and the water for operating the boiler could be used instead of the ballast, which is usually thrown out. We would thus obtain an apparatus capable not only of deviating at a considerable angle with ordinary winds, but even of following any route relative to the earth which might be desired." But we can charge against Dupuy de Lome the slight elongation which he gave to his balloon, while Giffard did not fail to give to his balloon the elongation of 7 to 1 in 1855, and that, too, without special precautions. Dupuy de Lome, with a balloon which was remarkably rigid, contented himself with an elongation of 2¼ to 1. Doubling this elongation, coupled to a motor of 8 H.P., would certainly have given very fine results. I may add that the balloon was not made, as we have said, for they understood very well that it would be impossible to avoid the use of the safety hydrogen valves of the balloon. The sides of the balloon had not been designed with a view of supporting a very great pressure, and the lower valve was regulated so as to allow air to escape as soon as its pressure exceeded that of the atmosphere.

The trial was made at Vincennes at the beginning of 1872; the inventor was accompanied by Mr. Zede, Engineer of Naval Construction, and Mr. Yon. In spite of a wind of 39 ft. per second speed and some accidents on the way, they obtained a deviation of 12°. The anemometer, which was immovable as long as the screw was standing still, turned as soon as the latter was started. The stability was perfect, according to the report of Dupuy de Lome. The car experienced no oscillation under the action of eight men working at the crab driving the screw, and they could easily have carried several persons more on either hand, or at front and back, without perceiving any movement whatever. The floor of a room could not have been more steady or level. Evidently the center of gravity in rising had a slight change along the vertical of the whole system, including the balloon and the car; but it was impossible to perceive any movement of the car relatively to the balloon, analogous to the oscillations of a floating boat, where the attachments and furniture are apt to be thrown about. Although Dupuy de Lome was not able to move against the wind on account of the insufficiency of his motor, his work resulted in the following expression of a committee appointed to be present at his trial: "It serves as a starting-point for the question which has been kept in a vague condition up to the present time, and of also serving as a necessary point of departure for all who wish to continue in this direction."

Mr. Tissandier.—It would seem that with Dupuy de Lome the aeronaut had said his last word, but a pupil of Giffard, who was an heir at the same time of the energy of his master, resolved to undertake new trials with a machine from which all sorts of marvels were expected—namely, the electric motor. It is evident, furthermore, that the dynamo which works without fire and without any variation in weight is not without its advantages from the aeronautic point of view.

The characteristics of the balloon which Mr. Gaston Tissandier constructed, with the assistance of his brother Albert, were as follows (fig. 8):

1. The dynamo was of the Siemens type. It was driven with a battery of the bichromate of soda very ingeniously arranged, so as to reduce the weight and obtain the greatest possible effect. The motor weighed 121 lbs. and the cells 496 lbs., and they contained liquid enough to work for two hours and a half. They were thus enabled to obtain $1\frac{1}{2}$ H.P. on the shaft of the machine, which put the average weight per horse power per hour, during the time that it lasted, a little more than 330.6 lbs. The screw had two arms, and was 9 ft. 1 in. in diameter; it was only controlled in its movements to a variation of $\frac{1}{16}$. This was one of the disadvantages inherent in the motor itself.

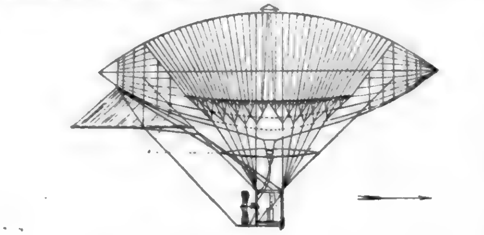


FIG. 8.

2. The balloon was spindle-shaped and had a capacity of 35,316 cub. ft., with a length of 91 ft. 4.4 in., and an elongation of 3 to 1; it was provided with an automatic valve at the bottom.

3. It was covered with a housing terminating in shafts of flexible wood, from which the suspension cords started. These latter were fastened by a crown in the crib, having for its object that of distributing the traction equally. This arrangement certainly does not give an absolutely equal distribution of the strains; I nevertheless feel that there was a certain efficacy about it.

The great defect with Messrs. Tissandier is that they did not profit by the works of Dupuy de Lome to insure the rigidity of suspension and the invariability of shape. Finally, they did not pay any more attention than their predecessors had done to maintaining the balloon absolutely in a horizontal plane. It is true, that with the electric motor they did not have, as Giffard did, the loss of ballast, which was due to the consumption of water and fuel; but this cause of instability is unfortunately not the only one.

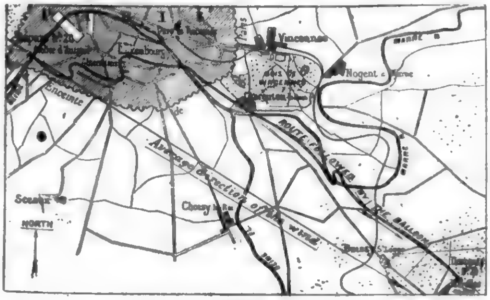


FIG. 9.

At the ascension of the balloon in 1883 the two brothers went up together, and made a good showing. Starting from the earth in a calm, they went up to an altitude of 1,640 ft. As generally happens up there, a wind of 10 ft. per second velocity was encountered, against which they could make no headway. Thus they stopped for some seconds above the Bois de Bologne, but they were troubled by giratory movements which increased in velocity as they sought to work against the current. The aeronauts, therefore, concluded that the rudder was not sufficiently efficacious.

At the ascension which was made in 1884 the motor developed 1.5 H.P., and the rudder, which was of larger dimensions, was placed at the back end, so that it extended out beyond the poop. The triangular portion next to the balloon formed a sort of immovable transom; the back part was moved by means of two lines passing over pulleys. The wind had a velocity of about 10 ft. per second, and the speed of the balloon was about 13 ft. per second. After having practically followed the line of the wind, during which the movements of the rudder turned them aside a little, the balloon, describing a semi-circumference, found itself with the wind ahead, and was navigated in this way for about 10 minutes directly above Grenelle. It repeated with the same success the same experiment above the observatory. Finally, before coming down, the wind having greatly diminished its velocity, they could go up against the current with great facility. "If we had had an hour before us," writes G. Tissandier, "it would not have been impossible for us to have come back to Paris."

Thus in three attempts, and during some minutes each time, the Tissandier brothers have been conquerors of the elements. It was a fine result, if we consider the difficulties which were met in this undertaking. The original construction had a volume of about 105,000 cub. ft., and cost about 200,000 francs. M. Tissandier made an appeal to the public and to scientific societies, but they scarcely obtained 4,000 francs. It is a sign of the times, which shows in what disfavor experiments with balloons are regarded. Left to their own resources, they were compelled to reduce the volume of the balloon to 35,316 cub. ft. M. G. Tissandier obviated a part of the disadvantages which the reduced volume caused them, by discovering a means of preparing very pure hydrogen, which possessed the remarkable ascensional force of .12 lbs. per cub. ft.

Although the trip, which was otherwise conclusive, had been made at Chalais before the ascension of 1884, others will not forget the grandeur of the effort made by M. Tissandier, and their absolute disinterestedness. Patriotic promoters of military aeronautics in 1870, these two men gained the recognition of their country.

(TO BE CONCLUDED.)

TESTS OF METALLIC TIES ON THE BELGIAN STATE RAILWAYS.

SINCE the establishment of the Belgian State Railways the management have been interested and engaged in the solution of the question of metallic supports for rails. Previous to the year 1846 there were three systems of metallic ties already in existence on the line between Brussels and Antwerp—namely, the Poncelet, the Gobert and the Marshal systems. None of them gave satisfactory results. In 1853 the management of the Belgian State Railway laid 5,000 ties of the Greaves & Barlow system, but the results obtained both in regard to the stability and the maintenance of the track were not as favorable as might have been desired.

In 1867 a special commission was appointed for the purpose of examining the different types of metallic track fastenings which were being exploited or experimented with at this time, and commissioners were sent by the government into France and Holland. Their attention was called to the Vautherin ties, to those of the Société de Couillet and to those of Messrs. Le Grand and Salkin, and they proposed that the management make a trial of these on the tracks of the Belgian State Road. Before adopting this suggestion the management sent the same commission into France the following year for the purpose of having them visit the tracks and make a report on the question, whether those which had been cited were giving the same satisfaction to the engineers. The reports which were received at this time were less favorable. In spite of this quite a large number of Vautherin ties were laid in 1868. The results were very unsatisfactory. After an average of about six years they were removed from the track in order to avoid compromising the safety of the traffic. They had been covered with a thick layer of rust and had lost from 4.4 to 6.6 lbs. of weight, and a large number were cracked beneath the rail. The reason for this breakage was evidently due to the fact that these ties did not have a sufficient moment of resistance to withstand the deflective strains, which the passage of heavy freight trains put upon them, composed, as they are in Belgium, of 60 cars, hauled by powerful locomotives, especially upon certain sections of the line, as in the mountain passes of the province of Luxembourg, where the grades are as high as 1.8 per cent.

While these tests of the Vautherin ties were being carried on in 1869, the management also made some tests of the Le Grand and Salkin ties, which were condemned in 1873 on account of the bad results which they gave.

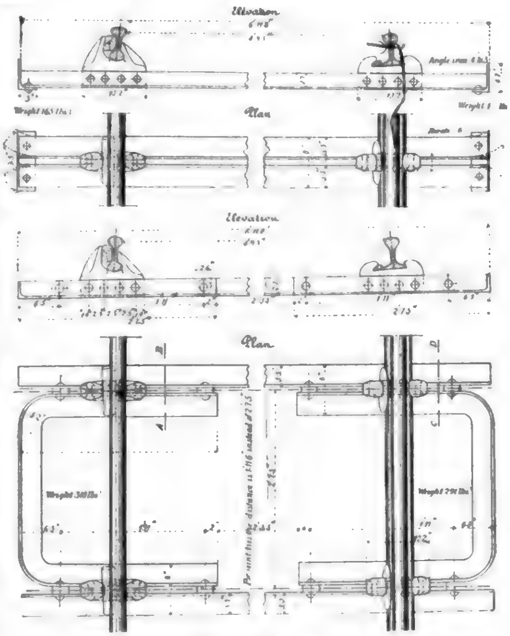
Between the years 1872 and 1879 the management made successive examinations into the designs of Hauwaert and Cabuy, of Kirsch, of Greef, of Potel, of Breten and of Wood, but did not see fit to make actual tests of any of them.

Another trial of an entirely metallic track was made in 1871 with the ties of Soignies de Schaerbeck, a new design, but containing nothing valuable, for these ties weighed 81.6 lbs., and were used under a strain of 106,618.5 lbs. per sq. in. They were only in existence one year. During the years 1878

and 1879 the management made some very extensive tests of the Hilf stringer for track, from which they expected good results. But here again, in spite of the very great care which was taken in laying the track and in the choice of ballast, which was of broken stone, gravel, and cinders, with the exclusion of all schistose matter, all broken so as to pass through rings 2.4 in. in diameter, they were not long in seeing that a favorable comparison could not yet be made with tracks laid on creosoted ties, either with reference to firmness of the track or expense of maintenance.

It was stated that the Hilf ties, which rested at their extremities upon metallic ties of the same transverse section as the stringers, with a single stay at the center of the length of the rail, did not guarantee that the lines of rails could be maintained in alignment. The chairs which held the rails to the stringers were not strong enough to resist the lateral thrust, due to the centrifugal force arising from the passage of trains over curves, and they were pushed to one side, working their attachments in such a way as to render them liable to cause serious accidents, especially derailments. Furthermore, it was also stated that under the disturbing action of the side lash of the trains, especially with locomotives having outside cylinders, the two lines of rails were given such a sinuous position, and it was increased by the passage of heavily loaded trains running under anything like express speed. The Hilf system of track, therefore, required for its maintenance very much more work, so that it was necessary to increase the size of the gangs of track layers and navvies. We may also add, in order to be exact, that the greater or less deformations, which were also produced in the vertical, were without doubt the cause of the great separation of the supports of the stringers; a circumstance as unfavorable as the preceding one to the preservation of the rolling stock, and to the security of the passage of the trains. The management of the State Railways after this new unfortunate experience, which was especially disappointing on account of the hopes with which they had entered into these tests, nevertheless did not immediately remove the Hilf stringers from their tracks. It attempted to remedy the matter by supporting the stringers at intermediate points between the supports, by putting in a third tie at the center of their length, and by further tying together two lines of rails with two stays instead of one. This was done on the line between Namur and Arlon, which is traversed by international express trains running between Libramont and Marbehan. The deformations, which have been indicated above, were diminished, but it was impossible to do away with them entirely. The notes in the memorandum and field books of the track department were always filled with fresh memoranda of the maintenance of this Hilf track, and were always greater in number than those relating to the standard track laid with Vignole rails upon oak ties of half-round form, with a height of 5.1 in. on a diameter of 10.2 in. and impregnated with creosote; until it was finally decided by the management of the Belgian State Railways, that they would remove the Hilf stringers from the main lines and lay them on the branch lines and switches at stations; or, in other words, on side tracks for standing trains and also on service tracks for furnaces, etc.

At the end of 1879 and in 1880 the management of the State Railways made a trial on a small scale of the Serres and Battig ties, between Buysinghen and Hal, on a high-speed line from Brussels to Mons; and at Angleur they tested some Helsen ties designed by the director of the Tardy & Benech Company, at Savogne, but, as happened with the others, the results were not very satisfactory. The average life of these ties was but a trifle over three years. In 1883 the management ordered its chief engineer to make a careful examination into the tracks and works laid under the Harrman system, which were of the stringer and cross-tie type, but the recent failure of the Hilf track prevented them from risking a test of a system of stringers. It did not consider it desirable to make a test of these ties on account of the complication of construction, which was considerably greater than that of the Vautherin system. It also refused to make any other experiments with the stringers and ties offered by Messrs. Caramin & Company, of Thy le Château, in the beginning of 1884. About the end of 1883 two engineers of tracks and permanent way, Messrs. Brudder and Braet, were sent into Germany and England to inquire regarding results obtained in these countries with metallic supports. The reports of these engineers concluded with the rejection of all the systems used in Germany, such as those of the Haarman, Heindl and Elberfeld outline, which was adopted by the Berg & March Railway on account of the expense of maintenance and lack of stability, since all of their ties fairly dance up and down under the passage of the trains and were the occasion of great deformations of track. The whole track laid with Webb's metallic system, which was visited by these men at Crewe, in England, was found in a very good condition, and, according to the reports received on the spot from the officers of the heads of the Equipment Department of the London & Northwestern Railway, the expense of maintenance was not at all burdensome, and hardly exceeded that of laying fresh track in the ordinary way upon their standard chairs. In this system of track, which is distinguished by its heavy dimensions, the rails, which are double-headed, weigh about 30.3 lbs. per ft., and rest upon steel ties weighing 161 lbs. The first expense of laying has been found to be considerably above the most solid of the Belgian lines. No new trial of entirely metallic track has been made since the report of these men.



THE PAULET TIE.

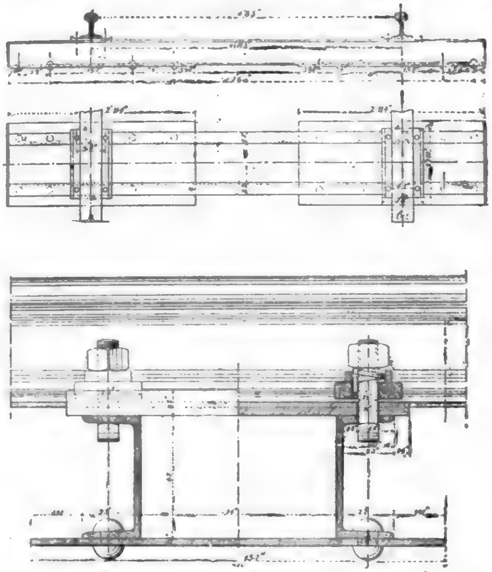
About the end of the year 1884 our international shops at Saraing, through the influence of its General Manager, M. Sadoin, pointed out to the Minister of Railways, Posts and Telegraphs the necessity of metallic supports on the Belgian railways, and proposed that he send a delegation of engineers into Germany, instructed to re examine the different systems of metallic supports which were used at that time on the other side of the Rhine. On receipt of this request the Belgian Government, which is always desirous of coming to the assistance of its national industries, appointed Messrs. Brudder and Tondelier, who were engineers of the Belgian State Railroads, to join a delegation sent by Cockerell, consisting of Baron Macar and Mr. Van Haesendenck. A remarkable report was drawn up by these engineers on their return from Germany, which, without being conclusive either for the adoption or rejection of any of the types examined, stated that, in the opinions of the German engineers, the best ties among those tested were those of the Elberfeld type, those of the Belgian State Railway, which were in the form of a hat, and those of Alsace and Lorraine, whose outline was that of a slightly modified Vautherin type. This report added that the Elberfeld tie beds itself well into the ballast, but does not offer sufficient resistance to the longitudinal sliding of the rail, and that its height is insufficient; that the hat-form tie of the Prussian State Railway is not easily tamped, and is not sufficiently strong at the bending joints; that the Alsace and Lorraine tie, with some of its dimensions slightly increased and strengthened, would be suitable for further testing.

In consequence of this report the management of the State Railways proposed to make a trial

1. Of the Alsace and Lorraine tie, improved as indicated above;

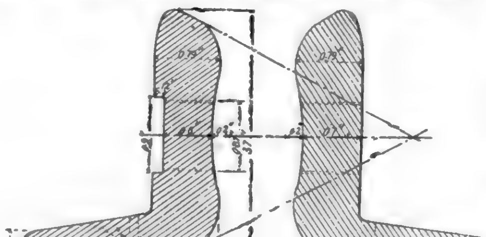
2. Of the Paulet tie (see engraving), which had been experimented with on branch lines, and which appeared at first sight to give good results. The State Railway of France had also just decided to make a trial on the Angeres line. At the same

time that the management made these propositions to the government the discussion of the railway budget was opened. Several members of the Chamber of Representatives, yielding to the desires expressed by the iron industries, urged very vigorously from the tribune that a new test upon a large scale should be made of metallic ties. The matter could not remain without some favorable consideration, and Mr. Vanden-



THE BERNARD TIE.

peereboom, Minister of Railways, took it upon himself to make a contract for the furnishing of 75,000 ties made up as follows: 25,000 metallic ties of Bernard type, designed by Mr. Bernard, who is Chief Engineer of the Northern Railway Company; 25,000 ties designed by Mr. Post, Chief Engineer of the Netherland State Railways; 25,000 ties designed by Mr. Braet, Engineer to the Minister of Belgian State Railways. These lots were ordered from the steel works of Couillet, of Angleur, of Seraing (Cockerill), who had given a bid of 149.5 francs, 119 francs and 119.5 francs per ton. The weight of these three types of metallic supports was taken by the management as equal respectively to 231.5 lbs., 165 lbs. and 165 lbs., which was considerably above that of the ties which had been previously tested. The adoption of this increase of



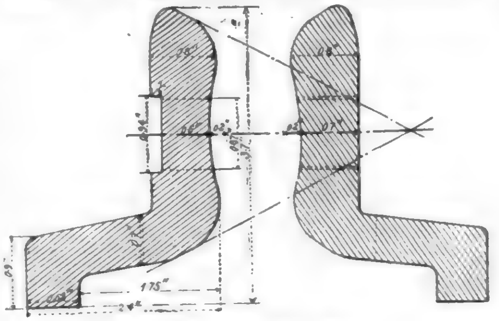
SPLICE BARS FOR BERNARD TIE.

weight was for the purpose of increasing the capacity for wear —that is to say, the durability of the supports, and in addition to stability the strengthening their resistance to bending strains; for it had been decided by the government that it would undertake a last experiment, in order to determine whether the replacing of wooden ties by those made of metal could give advantageous results.

It was furthermore decided that the trial in question should be made for the sake of a comparison of the three systems of entirely metallic track, by placing them under identically the same conditions of wear and with the same profile, alignement, and the amount of traffic which would pass over them. It may be added that in order to arrive at conclusive results they chose locations for placing the ties where the traffic was very rapid and heavy. Before passing on to the results which have thus far been obtained, it would not be devoid of interest, we think, if we gave a brief description of each of these ties—the Bernard, Post and the Braet.

Bernard Ties.—The Bernard ties tested on the lines of the Belgian State Railways were composed of two iron channel bars 7 ft. 6.6 in. long, attached at the bottom by two sheets 2 ft. 11 in. in length, riveted at their ends by eight rivets each. These sheets are bent up against the ends so as to close the trough of the tie, thus opposing a flat surface against the ballast in order to overcome all tendency toward lateral displacement. The rails were placed on the ties with the interposition of sole pieces or tie plates, which had an inclination of 1 in 20, and were provided on each side with an upward projecting clip. The rail was fastened to the tie by means of clips and bolts. In the arrangement adopted there were eight ties to each rail of 29 ft. 6.3 in. in length. The arrangement adopted by Mr. Bernard, in order to avoid the shearing off of the bolts, is as follows: The nut of the bolt is provided at its lower end with radial teeth, so that the annular nut-lock, which is in the form of a spiral and is placed between the nut and the clip, will hold better. Fig. 1 shows the general form of this spring. The lower end terminates by a vertical arm, which catches in a groove cut into the inside of the clip.

Post Ties.—The Post tie, which is in the form of an inverted trough, is the derivative of the Vautherin type, which was designed in France in 1863, at Fraisans, by Mr. Vautherin, at the Franche-Comte Works. It has a length of 8 ft. 2.4 in. and weighs 171 lbs. The incline of 1 in 20, which generally obtained in other systems of metallic ties, is easily realized, either by means of the Haarman arrangement, which consists of the interposition between the flange of the rail and the top of the tie of a sole tie-plate, or by means of the Hasch-Lichthammer device, which consists of obtaining this inclination at



SPLICE BARS FOR POST TIE.

the point of the support of the rails by stamping the tie when it is hot and giving it a concave outline in its longitudinal direction; and this has been done by Mr. Post by another process, in a way that does not deform the tie and in no way injures its stability. He has given this deformation to the surface of the support of the rail by rolling the tie, either with triple rolls or with a reversible roll by means of a special arrangement of the last grooving of the finishing rolls, and by taking care to obtain an excess of thickness of the metal at that portion which has to bear the greatest amount of fatigue.

As for the method of attachments, it consists of clips and bolts, with an interposition between the bolt and the clip of a nut of the double grooved or elastic type, which is in the form of a spiral arrangement which opposes unscrewing. This washer has a winged plate raised against one of the faces of the nut which was lately employed by the Belgian State Railway on the Vautherin ties. The elevation of the outside rail on curves is obtained by means of clips of different thicknesses, which are used sometimes in one direction and sometimes in another. The longitudinal sliding of the rails is avoided, in the case of supported joints, where the distance from center to center of ties is 1 ft. 9.7 in., by the use of angle-bars with a vertical prolongation coming down so as to abut against the clips.

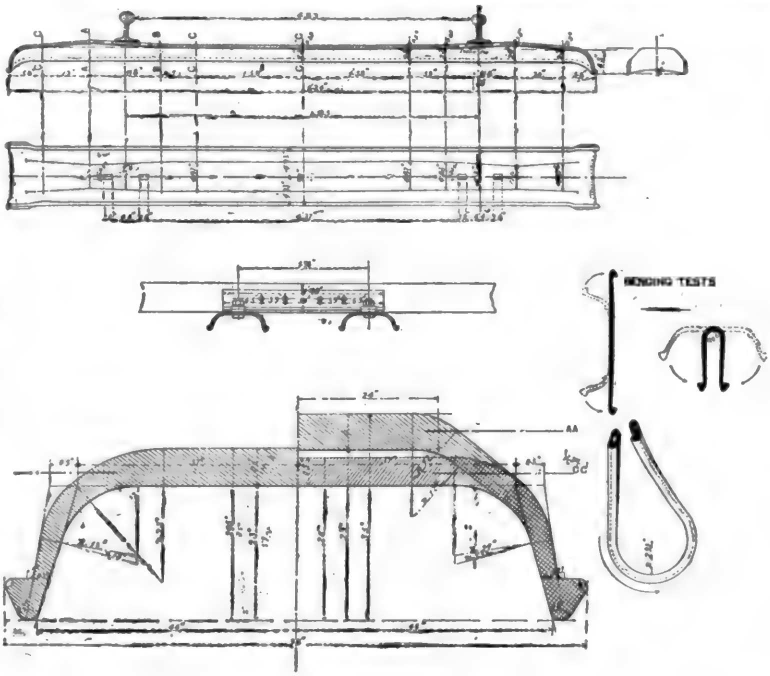
By closing the ends of the ties, by stamping down these ends under a press when hot, and by doing away with the horizontal rings and limiting the lower part of the support and their displacement by straight walls in the form of a knife which

cuts into the soil, Mr. Post has succeeded in overcoming a tendency of the tie to empty itself of its ballast. The latter is now imprisoned as though it were in a hollow, cannot free itself from the compression to which it is subjected, and opposes a strong resistance to the lateral displacement, especially on curves, and the whipping due to the passage of trains is almost entirely avoided.

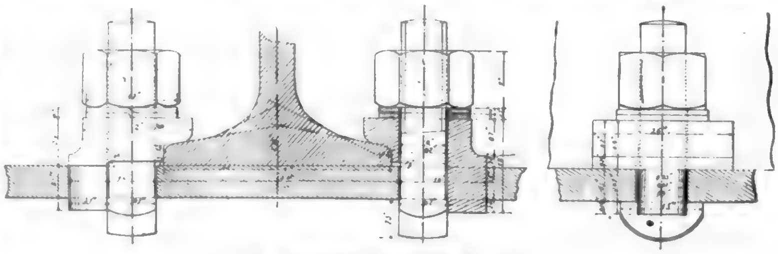
Braet Ties.—The Braet tie is nothing else than a modified form of the Post tie. The designer endeavored to approach in the transverse section of his support the circular form of equal resistance, and to give a greater rigidity to the track by retaining under the supports the greatest possible amount of ballast. The extreme outside edges of the tie are vertical, thus facilitating its penetration into the ballast, and they end, as in the Post tie, with strengthening pieces which protect the metal at this point against the blows of the tamping irons. The number of ties in laying the Braet track, as in the Post, was made 12 for each rail of 29 ft. 6.3 in. in length.

Results Obtained up to the Present Time.—Instead of distributing the ties to be tested over lines of various degrees of importance, the management, as we have already said, have them in use on the main lines which are doing the heaviest business, and on those where the speed of the trains is the highest. The test was therefore conducted so that the results would permit of the formation of a conclusion, and the test would be in a certain way a final one, and especially favorable to the metallic ties if the results had been satisfactory. Unfortunately these results have, unquestionably, been unfavorable, and it might almost be said that they have been disastrous, not only from the standpoint of the preservation of the supports, but also from that of the ordinary expense of maintenance of the tracks. Yet it must be remembered that nothing was neglected in order that the systems of ties tested should be capable of sustaining successfully all strains to which they might be subjected. During the course of the last year there was a most careful inspection made of the ties which were subjected to trial on the principal lines of the Belgian roads. After five years of service it may be stated that from 40 to 50 per cent. of the Braet ties showed cracks at the point of fastening, and these cracks were frequently as long as 1.1 in. The Post ties showed results less favorable still, only 20 per cent. having been found in good condition. In order to avoid these cracks, which were often produced in the steel when the holes are made on a punching machine, the edges of the holes were reamed out to a depth of .078 in. On the line between Brussels and Antwerp 77 per cent. of the Braet ties which were examined were found to be cracked, and 18 per cent. of the Post ties were in the same condition. Sometimes these cracks had attained a length of 1.96, 2.36 and even 2.75 in.; 5,000 riveted ties of the Braet type were removed from the track after only a few months of service. From the standpoint of preservation of the ties, the result of this test has therefore been most disastrous, and it was still more so from the standpoint of expense of maintenance. Points of observation were established along the different lines of the system. They were composed of sections laid side by side, in the same portions of the line under the same conditions of fatigue, and metallic ties of the Post and Braet systems. The exact account of the time which was spent by the graders and trackmen in caring for both types of track was kept by the men in charge of these observations.

The reports which were rendered on the line from Malines to Tirlemont gives as a result of the observation of this part of the track, which had the same length and was laid respectively with wooden ties, and the Post and Braet metallic ties, the hours devoted to each, as indicated above, was 356, 1,015 and 1,505 respectively, showing that the average of the work on the metallic ties was more than three times the amount of that required by the wooden. Such difference as this demands some kind of explanation. One of the first causes of this elevation of the cost of maintenance of metallic ties is that the metallic tie is hollow, and that the ends are closed in order to resist lateral displacement of the track. The tie thus imprisons in the hollow space beneath it a quantity of ballast, which soon becomes hard and compact. Then if the track requires redressing horizontally, it is necessary, first of all, to accomplish it by demolishing this mass of ballast. That is one of the difficulties which does not exist on a track laid on wooden ties, where it is merely necessary to remove the ballast which is banked up against one of the ends of the ties. The form of the tie renders it equally difficult to tamp the track properly. Finally, the last cause of this excessive expense of maintenance is not the least, and that is it causes a rapid deterioration of the ballast under its whole length.



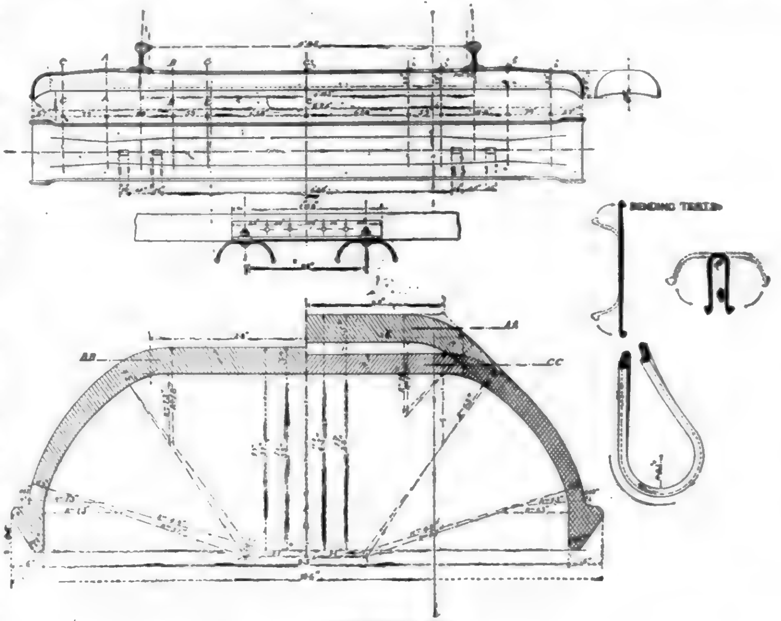
THE POST TIE.



RAIL FASTENING FOR THE POST TIE.

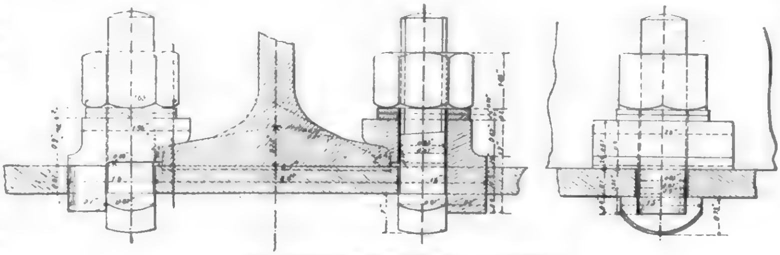
Mr. Flamache, who is Chief Engineer of the Belgian State Railways and Professor of the Course of Railway Exploitations at the University of Gand, presented a paper at the International Congress of Railways at St. Petersburg, giving the result of his researches on the deflection of the rail on the passage of trains.* The rail begins by rising above its normal place just ahead of the first wheel of the engine, it then lowers at the passage of each wheel, to rise again immediately between that and the passage of the next wheel, but in a proportion variable with the speed of the train and without exceeding at this time the normal plane of the track.

In the successive upward and downward movement the tie is constantly grinding the ballast, and the gravel which is in immediate contact with the hard metal is worn, broken and reduced to an impalpable powder. The hardest ballast is, therefore, at the end of a short time mixed with a certain quantity of fine powder. Then the rain comes, which percolates down through the ballast and the powder and reduces the latter to a mud. The upward and downward movement of the tie, which is hollow on the under side, therefore produces a partial vacuum, a suction and pumping action which draws the water down into the ballast beneath the tie and into the dust and mud which is mingled with it. At the end of a comparatively short time, then, the tie is buried in a mud ballast, which renders the track unstable, and which as soon as it dries forms a compact mass beneath the tie, which renders the work of track dressing so difficult. The only remedy for this state of affairs consists in either sifting the ballast through a screen, which is a very expensive operation, or of renewing it entirely.



THE BRAET TIE.

There is another point in the remarks which were made by Mr. Flamache which is of great importance. The diagram obtained directly by the registration of the movement and rail at the passage of trains shows that for low speeds and even average speeds the relative upward movement of the track after the passage of each axle remains practically very slight. It is only after a speed of 43.5 miles per hour is exceeded that these movements are suddenly exaggerated and their amplitude increased more rapidly than the speed itself. Finally, we think, with a great number of other engineers of permanent way, that metallic ties are hardly in a position yet to give good results on tracks where trains run at a speed greater than 43.5 per hour, at which speed the abnormal movements of the rails increase very rapidly, but we think that on some portions of the line which are run at lower speeds, these ties would give satisfactory results on condition that a proper ballast of good quality was used, but that they are less advantageous, economically speaking, than wooden ties, which give the only practicable elastic track thus far attainable.



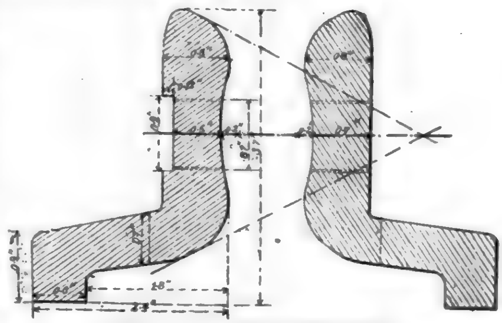
RAIL FASTENING FOR THE BRAET TIE.

THE CHINESE IMPERIAL RAILWAY.

From a correspondent in China we learn that Mr. W. N. Pettrick has resigned his position as Assistant Managing Director of this company, and with his departure all prospect of applying American railroad methods in China is over.

Mr. Pettrick attempted to introduce the Westinghouse air brake, but the English engineers did not look with favor upon the innovation; and now, although two locomotives are fitted with the brake, no use is being made of it.

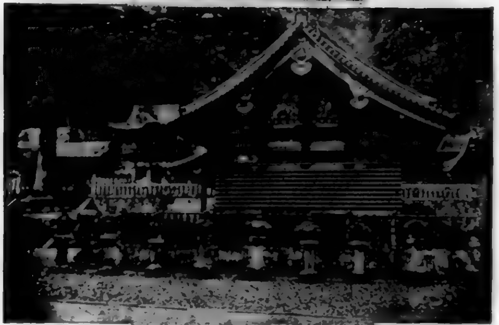
Immediately following Mr. Pettrick's resignation there was a change in the Chinese management of the road. The former Chief Director, Yang Hung tien, has been retired, and Chang Yen-moh has been put in his place. As Chang Yen-moh is known to be of strong German sympathies, it is thought that



SPLICE BARS FOR THE BRAET TIE.

*See American Engineer, August, 1893.

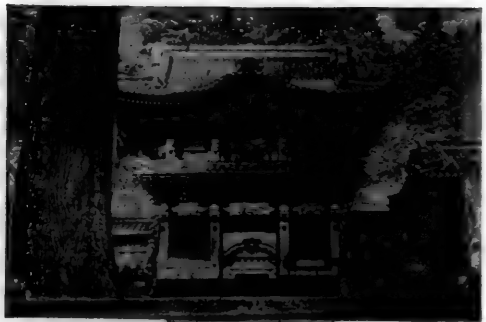
1. MIHASHI, SACRED BRIDGE



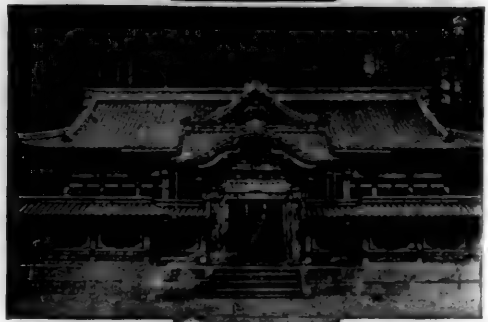
2. TAKARAGURA, GODOWNS

3. WATER CISTERN

4. LANTERN, COREAN



5. YOMEIMON, GATE



6. KARAMON, GATE

7. NITENMON, GATE

8. YASHAMON, GATE

NIKKO TEMPLES.

the German influence will now be the dominant foreign influence in railroad affairs. As yet nothing definite has transpired in that way.

The work on the Lan River bridge continues under C. W. Kinder, Engineer-in-Chief, and the railroad is being extended toward the north. It will reach Shan-hai-kwan, the military town at the eastern terminus of the Great Wall, this year.

It is now decided to run a branch line from Port Arthur, at the entrance to the Pe-chi-li Gulf, to New-chuang (?), so connecting Port Arthur with the military road from Tientsin to Kirin. Tenders for 4,000 tons of rails to be landed at Port Arthur not later than September 30 have been invited.

New iron works to be located at Tangshan, under German auspices, are projected, but their plans have not been definitely settled yet.

NIKKO TEMPLES.

The range of mountains known as Nikkozan is situated on the northwestern boundary of the province of Shimotsuke, in the southeastern part of the island of Nippon.

The highest point of the mountains lies in 140° 10′ north longitude. Its highest peak, Nantaizan, is 4,680 ft. above the sea, and 820 ft. above the lake of Chiuzenji (estimated to be about 3,850 ft.), lying at its northern base.

The name Nikko is well known to all Japanese and foreigners who have visited the most remarkable places in Japan, for its beautiful natural scenery and splendid temples, buildings, etc. The original name was Futa-ara-yama (the two storm mountains) on account of periodical hurricanes in spring and autumn, which issued from a great cavern in the mountain on the northeast of Chiuzenji Lake, and this name, being translated into Chinese, became Nikkorzan. In the year 820, the priest Kukai (or Kobo Daishi) visited the mountain, made a road to the neighborhood of the cavern, and changed the name Futa-ara-yama to Nikkozan (or the "mountain of sun's brightness"), from which time the storms ceased to devastate the country. Up to the end of the seventeenth century a family of Shinto priests named Ono used to pay two visits every year to the cavern to perform certain exorcisms, the secret of which had been imparted to their ancestor by Kukai, and the effect was to keep the great storms quiet; it does not appear, however, that the discontinuance of this practice has had any evil results.

The sanctity of Nikkorzan dates from the year A.D. 767, when the Buddhist saint, Shodo Shonin, first visited it. Later on, in the beginning of the ninth century, Kobo Daishi, and in the middle of that century the priest Jikaku Daishi, added its sacred places.

In the year 1616, when the priest Ten Kai, afterward canonized as Jigen Daishi, was abbot, the second Shogun Hidetada, acting on the dying injunctions of his father, sent Honda Kadzusa no-suke and Todo Idzumi-no-kami to Nikko to find a resting-place for the body of Iyeyasu. They selected a site for the shrine on the southern slope of a hill called Hotoke Iwa, behind the temple where the Gongen of Nikko had been enshrined from ancient times, and returned to Yedo (Tokyo) on the 21st of the ninth month of the Japanese calendar with a plan of the spot for the information of His Highness.

Kadzusa-no-suke was appointed chief superintendent of the works, and the buildings were commenced on the 17th of the eleventh month of the same year. In the third month of 1617 the shrine and some of the surrounding edifices were completed. On the 15th of the same month the corpse was removed from Ku-no-zan, in Suruga, where it had been temporarily interred, and the funeral procession started for Nikko, where it arrived at two o'clock in the afternoon of the fourth day of the fourth month. On the eighth day the coffin was deposited in the tomb.

On the 11th Shogun Hidetada paid a visit to the shrine, and three days later the title of Sho-ichi-i Daigongen (first rank) was conferred on the deified hero by a decree of the Mikado (Emperor of Japan), which was read by his envoy, Ano Saishio, a Kuge (emperor's subject).

On the 17th the Gohei (shreds of paper attached to a long wand finely decorated) was presented at the chapel by the Imperial Envoy, and on the following day offerings were made at the shrine by the local Buddha Yakushi.

During the 20th, 21st and 23d days of the same month the Hokke Sacred Classic was read 10,000 times by priests assembled for that purpose. Many Kuge and a priest belonging to the Imperial family took part in the proceedings.

In the year 1644 the Abbot Tenkai (a wise man who has been respected by first Shogun Iyeyasu and his successors) died and was succeeded by the Monzeki, of Bishamondo, a son of the Sadaijin Kwa-zan-In-Sadahiro, who resigned his office 10 years later and returned to Kyoto.

The second Monzeki was the Priest-Prince Morizumi, the fifth son of the Emperor Go-Midzu-no-o. From his time down to the revolution in 1868 the chief priest of Nikko and Toyeizan (Uyeno) had always been a prince of the Imperial blood. He usually resided in Yedo (Tokyo), and visited Nikko three times a year—namely, at the new year, in fourth and ninth months.

The title of Dai Gongen was changed to that of Miya or Goo in the year 1645 by decree of the Emperor, conveyed by his envoy, the Dai-na-gon Kikutei Tsune Saye. There are only 21 shrines in Japan known as Goo, the highest title which can be given to them. Miya or Goo means palace, and Tosho means the light of east, in allusion to the seat of Iyeyasu's glory having been in the eastern part of Japan, and to the benefits he conferred upon this country by putting an end to the civil war which had distracted it for so many generations.

Iyemitsu, the third Shogun of Tokugawa, who consolidated the power established by his grandfather, died on the 20th of the fourth month of 1651, and was buried within the grounds of the shrine of Nikko on the sixth day of the fifth month of the same year. The posthumous title Taiyu In Den was conferred upon him by the Emperor.

1. Mihashi (Sacred Bridge).

On issuing from the gate at the top of the street called Hatsuishi, and proceeding a few steps, one of the first objects which strikes the visitor is a crimson bridge spanning the rushing stream of Daiza-gaiva, about 30 yds. wide between the stone walls which confine its course at this point. It is supported by stone piers of great solidity, fixed into the rocks between which the stream flows, and though not claiming any particular architectural merit, is interesting from the fact that it was formerly closed to all passengers except the Shoguns and pilgrims twice a year. It is called Mihashi, or the sacred bridge. The legend says that when the holy Shodo Shonin first visited Nikko and arrived at this spot, he found the rocks so steep and the flood which rushed between them so full of whirlpools, that it seemed impossible to pass over. Appalled at the sight he fell on his knees and called fervently upon the gods and upon Buddha for aid, when, in answer to his prayers there appeared on the opposite bank the indistinct figure of the god Shusha Daio holding two green and red snakes, which he cast over the abyss. In an instant a long bridge was seen to span over the stream like a rainbow floating among the hills. So great was the astonishment of the saint, that he doubted the reality of the miracle, but became fully convinced of the practical intervention of the god when the bridge in another moment became covered with long grass. Feeling quite satisfied about the safety of the structure, he crossed it with his disciples, and on turning round to look at it again saw, to his wonder, that the god and the snakes had completely disappeared.

The present bridge, which is 84 ft. long and 18 ft. wide, was built in 1636, and has not required any repairs of importance since that time. At each end there are gates, which are constantly closed.

The shrine of the god Shusha Daio stands on the side of the road opposite to the northern end. Forty yds. or so lower down the stream is the temporary bridge, successor to that which was constructed while the sacred bridge was in course of construction.

2. Takaragura (Go-Downs).

Enclosed by a wooden wall painted bright red there are, firstly, three buildings which are so beautiful that it seems a profanation to call them go-downs, but they are nothing more in reality. One is said to contain the utensils used at the ceremonies performed in honor of Iyeyasu's memory; the second contains pictures and Buddhist scriptures; and in the third are deposited furniture and other articles used by the hero during his lifetime.

The buildings are arranged in a zigzag form, the third being remarkable for two extraordinarily painted carvings of elephants on the side toward the gate. They are ascribed to Hidari Jingoro, a left-handed sculptor, who was very celebrated for fine arts of sculptures. It will be noticed that the joints of the hind legs are represented as bent in a weary way.

3. Water Cistern.

An interesting object is the water cistern made of a solid piece of granite and protected by a roof supported upon 12 square pillars of the same stone. It is so carefully adjusted that the water, conducted through a long series of pipes from the cascade called Somen-ga-taki behind the hill, bubbles up

and pours over each edge in exactly equal volumes, so that it seems to be a solid block of water rather than a piece of stone. The honor is due to Nabeshima Shina-no-no-Kami (Prince of Hizen), who presented it in 1618.

4. LANTERN (COREAN).

This is also a fine solid piece of workmanship, but its style and construction indicate that the credit of its manufacture is not due to artisans of Corea. We should be inclined to say that all three of these gifts came from Europe through Dutch hands, and the form of some bracket candlesticks, which are attached to the interior wall of the court and left of the steps, suggests that the whole set may have been the spoil of some Roman Catholic church in the Netherlands. No Corean or Liukuin ever made a candlestick with a hollow socket for the candle.

Nothing else remains to be observed in this court except two iron standard lanterns on the right of the steps, presented by Date Masamune, Prince of Sendai, a prominent adherent of Iyeyasu, and the same number on the left, given by the Prince of Satsuma. The whole number of such lanterns contributed by various Daimios amount to 118.

5. YOMEIMON (GATE).

This gate stands on the platform, after ascending a flight of steps, and is a marvel of workmanship. Photo 5 shows the front view and 6 the back view of the gate. Wooden columns of Keyaki timber are painted white as well as the interior of the side inches, which are lined with arabesques of graceful design founded upon the "botan" (mountain flowers).

The capitals of the columns are formed by the heads of fabulous animals called Kirin. Above the architraves the railing protects a balcony which runs all round the structure, supported by dragons' heads, with two white dragons fighting in the central space. Underneath are a row of groups of holy children playing, and other subjects, nine on each side. Below, again, is a curious network of beams and seven groups of Chinese sages. The roof is supported by gilt dragons' heads with gaping crimson throats, and from the top a gilt demon looks down upon the spectator. On the right and left extend a long piazza, the white walls of which are adorned with magnificent carvings of trees, birds, and flowers colored after nature. There are 15 compartments on the right and six on the left.

6. KARAMON (GATE).

This is composed of Chinese woods inlaid with great skill and care. The chapel is not open to the Japanese public, who are not admitted further than the bottom of the front steps, surmounted by the usual mirror. Foreigners and some classes of natives are not permitted access to it.

The front hall is a large matted room, 42 ft. long by 27 ft. from back to front, with two antechambers, one on each side. That on the right was intended for the use of the Shogun, and contains, besides pictures of Kirinona, gold ground, four carved oaken panels 8 ft. high by 6 ft. wide. The subjects are the phœnix variously treated, and appear at first to be in low relief, but on closer examination it will be discovered that the figures are formed of various woods glued to the surface of the panel, a suspicion of which fact is also naturally excited by a quantity of false headed nails, which do not add to the beauty of the work. The same number of panels, the subject of which are eagles, very spiritedly executed, exist in the opposite antechamber, called the waiting-room of His Highness, the abbot.

The golden Gohei, in the center of the front chapel, is the only ornament left, the Buddhist furniture of bells, gongs, books of prayers, etc., having been removed. Two wide steps at the back lead down into that part of the chapel called the stone chamber, from the circumstance that it is paved with that material. The ceiling is divided into square panels, painted with golden dragons on a dark blue ground. Beyond are some gilded doors leading into the Honden (principal chapel), containing four apartments, to which access is not obtainable. In the first stood formerly the Gohei, in the last probably the Ihai (a tablet inscribed with the name of Toshogu).

7. NITENMON (GATE).

The niches on the outside contain a green wooden statue on the right and a red one on the left. One of the niches on the inside is occupied by the God of Wind, painted green, who carries on his back a long sack tied at each end, with the ends brought on his shoulders. He has only two toes on each foot and a thumb and three fingers on each hand. His companion, the God of Thunder, is painted red, and holds a thunderbolt in his right hand. He has the same number of toes as the God of Wind, and one finger less on each hand. The name Nitenmon means gate of the two heavenly gods of wind and thunder.

8. YASHAMON (GATE).

This gate stands three more flights of steps distant from the above gate, the niches of which contain four Yasha, Buddhist gods, who protect the four quarters of the compass.

THE FASTENINGS OF RAILS TO WOODEN TIES.

BY JULES MICHEL.

FOR some time engineers have been turning their attention toward the substitution of wood screw fastenings for spikes or pins, which are driven into place by blows of a hammer, in fastening rails to wooden cross ties. This question, which is of more importance for rails which rest directly upon their flanges than for double-headed rails which are carried by chairs, was discussed at the International Congress of Railways at Paris, and afterward at the Congress of St. Petersburg. It has given rise to very different opinions, doubtless because those most interested do not agree upon the type of fastening which they would use. The result is that while wood screws are very severely criticised in some countries, they have given the best of satisfaction elsewhere.

In order to bring the question to a definite focus, I would like to recapitulate some experiments which have been made during the past twenty years upon a large scale by the Paris & Lyons system of railways to illustrate the type which has been evolved as the result of these experiments and to indicate the modifications of which it would appear susceptible.

Since 1863 the Paris, Lyons & Mediterranean Railway have used an iron screw for fastening their rails; this screw was cut cold, and the threaded portion had a length of 4.9 in. Fig. 1.—The diameter of the head was .8 in., while the body of the screw was only .55 in., leaving a projection on each side of .12 in. for the thread, the pitch of which was .3 in.; the base of the triangle forming the thread was .16 in., and was divided into two unequal parts of .06 in. and .10 in. by the perpendicular let fall from the apex. This fastening seems to have been very carefully designed, especially when compared with the lag screws or screw spikes used for some years previously in Germany.

Fig. 2 shows the fastening used on the railways of the Grand Duchy of Baden previous to 1860; they started it by striking with a hammer just as they did also the spike shown in fig. 3. The hole was not bored in advance; and it will readily be understood that under these conditions the fastening would destroy the fibers of the wood and would give poor results as a method of fastening the rails to the tie.

The fastening of the Paris, Lyons & Mediterranean Company was started in a hole .63 in. in diameter, which was bored with a bit into hard wood, either oak or beech. It had the inconvenience of taking some time to fasten, and the wood which lay in contact with the body of the screw between the thread was only .14 in., and this was found to be insufficient. Its use, therefore, was limited to changes which were made in the track, and efforts were made to improve the spike, to which, after a number of tests, the form of the octagonal prism shown in fig. 4 was given.

This spike gave very good results; and recently some foreign engineers, who have adopted it on account of its superiority over other types of spikes, have told me that the results were perfectly satisfactory to them, and they could see no need of replacing it with a screw spike.

It has a length of 5.9 in., including the head; the prismatic body is made with a vertical distance of .75 in. between faces and .8 in. across the angles. It is fastened by blows of a hammer into a hole previously bored with a bit having a diameter of .63 in. It shows considerable resistance on entering, and compresses the fibers of the wood. In the July issue (1884) of the *Revue Generale des Chemins de Fer* I gave the resistance which it offered to pulling in different kinds of wood—that is to say, it shows from 3,970 lbs. to 5,750 lbs. in hard wood. The spike weighs .77 lb., and costs on an average about two cents apiece.

But with the development of the track and the increase of speeds, the resistance which this spike offered to pulling seemed insufficient, and engineers have turned their attention toward the substitution of screw spikes.

Since 1863 the Northern and Eastern Railway companies,

whose types of spikes are shown in figs. 5 and 6, have found them to be very defective, and have had recourse to the screw spikes shown in fig. 7 for use with wooden ties on their main line. These screws have about the same dimensions as those of the Paris, Lyons & Mediterranean Company, shown in fig. 1, which bears a close resemblance to that shown for the Eastern Company.

In 1875, in consequence of the experiments which were given in detail in the July number of the *Revue Generale des Chemins de Fer* for 1884, the screw spike was adopted by the Lyons Company to the exclusion of the ordinary spike, and it was given the form shown in fig. 8, which bears a strong resemblance to the type of the Northern Railway Company, but which was considerably improved by increasing the pitch of the thread. The prism of wood included between the two threads which must resist the pulling had a height of about .39 in. instead of .27 in. Its resistance was therefore theoretically about double, and the fibers of wood were better arranged during the operation of putting it in position.

At the same time the question of the use of the screw spike was discussed at the union of German railways, and afterward at the eighth reunion of the Verein in Stuttgart in 1878. The committee concluded by recommending the use of screw spikes instead of ordinary spikes for fastening rails to the ties.

The screw spikes adopted by the Paris, Lyons & Mediterranean Company was first manufactured of iron and the thread cut cold. About 1878 they tried to manufacture the threads by hammering hot in suitable dies. This hammering produced a useful shaping of the material, but it required great skill on the part of the workmen, and very frequently the threading was defective. Nevertheless, it was used, together with the cold threading, to facilitate the production in the large quantities necessary for the consumption of the old and new lines, the latter of which showed a development of about 124.27 miles per year.

But the shaping of the metal to obtain the hexagonal head adopted in imitation of the Northern Railway Company's type was a somewhat delicate operation. It required so much heating that the iron was frequently burned and the head of the screw was sometimes torn off. The wrench which was used for driving and withdrawing the spike was of such unwieldy dimensions that breakages and twistings were caused by the strains to which the spikes were submitted, or the thread began to cut into the body of the screw, so that the resistance of the metal was insufficient to carry the strains.

As soon as the conclusion was reached that it was necessary to increase the solidity of the track attachments the dimensions of the body of the screw were increased, just as the Northern and Eastern Railway companies, who had found the same disadvantage, and had adopted an iron screw spike .9 in in diameter with a diameter at the base of the thread of .67 in. instead of .55 in., which they had previously used, had been obliged to do. This is the dimension which is still used by these companies. Figs. 9 and 10 show the last type of screw spike adopted by the Northern and Eastern Railway companies, and fig. 11 is the type used by the Belgian State Railways for the Goliath type of the Vignole rail.

But as the change in the diameter of the attachments on the tracks of the Paris, Lyons & Mediterranean Company, where they use chairs having holes .8 in. in diameter, could not be made without redrilling all these holes, they decided, after a certain number of tests, to have recourse to steel in order to secure greater resistance against rupture ; at the same time they adopted the spherical form for the head like the Eastern Railway Company, fig. 7. This was done in 1881, and since that time the use of steel has been adopted in the regular manufacture of the heads of the screw spikes, and furthermore threading them cold by rolling by means of a three-roller machine.

These machines were not successful with iron because they caused cold shuts, but have given excellent results with steel. A single machine can turn out about three thousand screw spikes per day without overworking the attendant who controls it, and without the rapidity of the operation injuring in any way the regularity of the output.

Finally, in 1889 new experiments were undertaken to determine whether it would not be possible to increase the pitch of the thread for the sake of rendering the placing of the spikes more rapid without injuring their pulling resistance.

In consequence of these tests, which are given in *résumé* in the accompanying table, the scr. w spike (fig. 13) was adopted. It consists of nine spirals with a pitch of .5 in. The base of the thread is .12 in. ; the outline of the thread is a triangle intermediate between a rectangular and an isosceles triangle. The head is like a flattened cap surmounted like a square prism for the wrench which is used in driving it. It is manufactured hot by rolling from mild steel, the tensile strength of which ranges from 101.4 lbs. to 110.2 lbs., and an elongation of 25 to 28 per cent. The weight is .09 lbs., and it cost about three cents. It, therefore, costs one cent more than the old iron spike, but the pulling resistance is tripled, and there is no more trouble with the rails tearing the fastenings from the ties, as formerly occurred after a few months of service. This loosening of the fastenings caused a very injurious wearing of the flange on the chair or the tie, and permitted the sand of the ballast to get beneath the flange of the rail so that the wear was more or less rapid according to the intensity of the traffic.

The conclusion is, then, that the use of a screw spike of some carefully designed shape assures the stability of track and increases the life of the rails, chairs and ties.

It may be furthermore added that it never enters the mind of the track layers who have a cross-handled wrench to use a hammer to drive these screw spikes with threads either projecting or slightly inclined.

The hole into which they are driven should be from .55 in. to .59 in. in diameter, according to the diameter of the body of the spike and the nature of the wood of the tie, whether it be pine, oak or beech. The wood is compressed by the entrance of the threads, which force their way in, and the friction of the body upon the fibers of the wood compresses it still more, thus adding to the resistance of the threads which oppose any loosening of the spike. After they have been laid for a few weeks they are usually screwed up afresh, not because the spike is loosened in any way, but because the surface in contact—rails, chairs and ties—have, so to speak, effected their seating, and are exactly adjusted to each other by the pressure to which they have been subjected by the passage of the trains. From this time on the fastening is complete. The following table gives a *résumé* of the tests made in different ways by the permanent way department of the Paris, Lyons & Mediterranean Company :

STRAINS REQUIRED TO PULL SCREW SPIKES OF .8 IN. AND .9 IN. DIAMETER WITH A PITCH OF THREAD OF .4 IN. AND .6 IN. DRIVEN 4 IN. INTO VARIOUS KINDS OF WOOD OF DIFFERENT AGES.

NEW WOOD JUST PUT IN TRACK.

Date of Test.	Diameter of Spike.	Pitch of Thread.	Northern Pine.	Landes Fir.	Beech.	Oak.	Diameter of Hole in Wood.	Observations.
	In.	In.	Lbs.		Lbs.	Lbs.	In.	
1875....	.8	.4	5,700	....	9,500	9,000	.6	
1881....	.8	.4	..	....	10,000	10,600	.6	10 tests.
1889....	.8	.4	...	....	.... ..	11,600	.55	Spikes rolled, 24 tests.
1889....	.8	.5	....	....	.. ....	12,800	.55	20 tests.
1889....	.8	.6	....	....	......	11,500	.55	10 tests.
1891....	.8	.5	7,600	11.4	.....	.. ..	.55	
1889....	.9	.5	....	...	13	12,300	.67	4 tests.

WOOD THAT HAS BEEN IN TRACK FOR NINE YEARS.

1889....	.8	.4	....	...	......	10,000	.55	10 tests.
1889....	.8	.5	....	....	.....	11,600	.55	

The conclusion reached from the tests of 1875 and 1881 is that the average resistance to pulling is the same in beech and in ordinary oak or about 9,900 lbs.

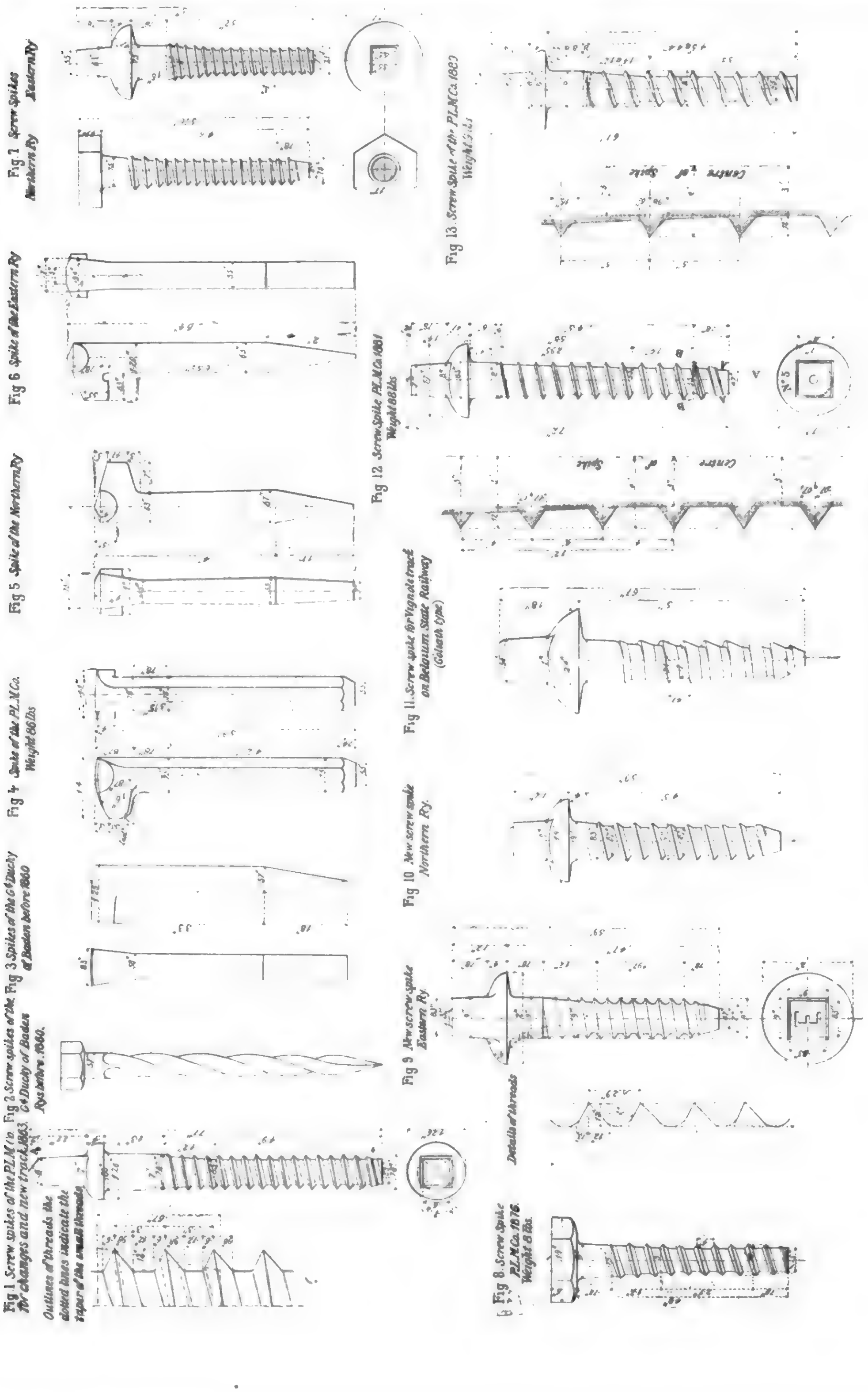
The improvement in the manufacture by rolling the screw spikes hot out of steel which was developed in 1889, added to the reduction in the diameter of the hole in the wood, has increased this resistance about 15 per cent. and raised it to 11,500 lbs.

The modification of the pitch which was raised from .4 in. to .5 in. has also increased this resistance by about 10 per cent., or raising it to 12,800 lbs. in fresh wood and 11,500 lbs. instead of 10,430 lbs. in wood that has been 9 years in service. This gives an average of 10,965 lbs. in ties as they are ordinarily found in service.

The increase of the pitch to .6 in. seemed to have the effect of lowering the resistance, which was only 12,300 lbs. against 12,800 lbs. with the pitch at .5 in.

Finally, the screw spike with a diameter of .9 in. and a pitch of .4 in. with the base of the thread only .12 in. did not seem to give any better results than the .8-in. screw spike with a pitch of .5 in. either in Northern pine or in oak.

An attempt was then made to give the thread a section which would be either an isosceles triangle, a right-angle triangle, or some intermediate form such as that which was adopted on the



TYPES OF FASTENINGS FOR RAILS AND WOODEN TIES.

Paris, Lyons & Mediterranean road in 1863 (fig. 1). Tests which were made in 1889 have given the following results as the strain which is required to pull different kinds of screw spikes .2 in., either in new oak or in ties which had been nine years in service.

Dimension of Spike.	Isosceles Triangle.	Rectangular Thread.	Observations.
Screw spike of .8 in. diameter.			New tie.
Pitch of .4 in	11,680 lbs.	12,039 lbs.	Average of 4 tests.
Pitch of .6 in.	12,460.5 lbs.	12,513 lbs.	Average of 4 tests.
Pitch of .5 in.	13,000 lbs.	13,560.75 lbs.	Average of 4 tests.
Screw spike of .9 in. diameter.			New tie.
Pitch of .5 in.	13,424 lbs.	13,424 lbs.	
Screw spike of .8 in. diameter.			Tie having 9 years' service.
Pitch of .4 in.	10,253 lbs.	9,922 lbs.	
Pitch of .5 in.	10,253 lbs.	11,576.25 lbs.	
Screw spike of .9 in. diameter.			Tie having 9 years' service.
Pitch of .5 in.	11,250 lbs.	11,020 lbs.	

These tests do not actually seem to give any preference to the rectangular form of thread over that of the isosceles triangle; hence the Lyons Company has kept the form which it has used for a long time, there being no reason for changing.

We can conclude from the tests given in the first table of this article what may be the capacity to resist pulling for oak which has been compressed by the introduction of threads of the spike .8 in. in diameter into its fibers. The resistance to pulling, according to the experiments of 1889, is 12,800 lbs. This is obtained by the pressure of nine coils of .12 projection and 11 × .7 in. as the average diameter, forming a total surface of 9 × .25 sq. in. = 2.25 sq. in., can by the friction of the body of the screw of .55 in. on a height equal to two-thirds of the body to which the spike has been driven, since the thread occupies .2 in. out of a height of the pitch, .5 in. Now, a direct test for a smooth stem .55 in. in height gives a resistance to pulling of 3,307 lbs. It may then be admitted that the body of the screw itself would produce a resistance of 2,205 lbs., thus leaving 10,639 lbs. for the pressure on a surface of 2.21 sq. in., which supposes a resistance of 4,459 lbs. in new wood.

For ties which have been nine years in service, the resistance would be only 9,371 lbs., or 4,200 lbs. per sq. in.

According to the tests published in 1884, the resistance of new oak to compression is 529.2 lbs.; the fibers of the wood bend back by the operation of the screwing of the spike would increase its resistance 40 per cent.

The steel of which these spikes are manufactured has a resistance to rupture of from 64,000 lbs. to 71,000 lbs. per sq. in. or 10 × ¼ the resistance of the wood of the ties which have been several years in service on the tracks, to compression. It is not out of place to ask whether a better model of spike would not cause the two materials in contact—that is the steel and the wood—to work together up to the limit of resistance of which they are capable.

The Paris, Lyons & Mediterranean spike does not fulfill this definition, for the metallic center resists a strain of 15,435 to 17,640 lbs., giving an average of 16,537 lbs. before breaking, while the wood yields under a strain of 12,844 lbs. in wood nine years old, and 11,576 lbs. in old wood, giving an average of 12,120 lbs.

The surface of the threads would then be increased to the detriment of the body of the spike at least by increasing their number and lengthening the part covered by the thread. Supposing then that the diameter of .8 in. for the outside is retained, it would be necessary to give the body a diameter of .5 in. or a surface of .2 sq. in. instead of 2.4 sq. in., which the body of .55 in. gives. The resistance to rupture would then be only 12,780 lbs. for a steel spike. If the body had a diameter of .5 in., the threads would form a projection of .14 in. on each side. In a direction on a plane at right angles to the axis of the spike, each turn of the spiral would have a surface of 2¼ sq. in. If there are nine complete turns, the total surface of the thread brought to bear against the wood will be 2.56 sq. in. instead of 2.23 sq. in. as in the spike actually used, or an increase of .33 sq. in.

The resistance to pulling will then increase by .33 sq. in. × 740 lbs. or 259 lbs.—that is to say, instead of 12,120 lbs. we would have a resistance of 13,818 lbs., which is almost exactly equivalent to the tensile strength of the body of the spike. If instead of hard-wood ties, like oak or beech, soft-wood ties should be used, such as Northern pine, it would be necessary to increase still further the projection of the thread at the expense of the diameter of the body by basing it on the coefficient of resistance to compression of the soft woods.

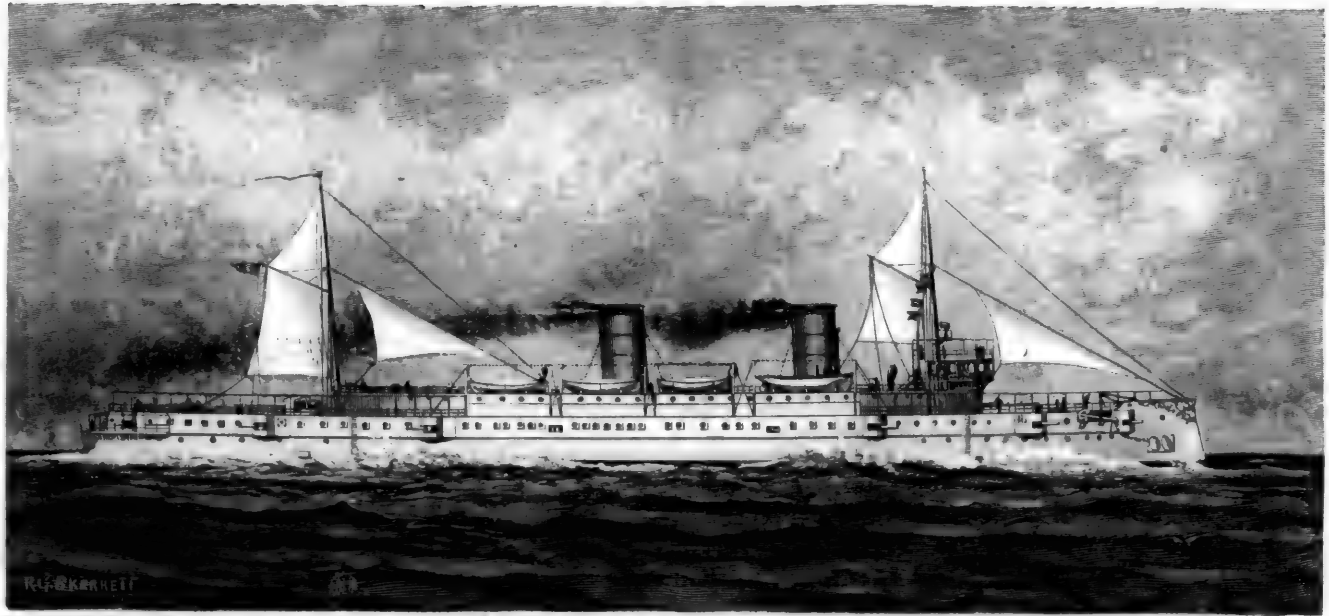
It would then be desirable to increase the projection of the thread of the spike used by the Paris, Lyons & Mediterranean Company by a small amount. They are not considering the advisibility of increasing it proportionately to the length of the ties as it has practically remained, after several years of use, and after the strains to which it is subjected scarcely more than 4.7 in.

The remarks which we have just made may appear to be somewhat theoretical, but they can at least serve as a guide to engineers who are devoting their attention by replacing spikes which are still in use by a carefully designed lag screw, where the material would be utilized in a rational way. These investigations are not without their value, for if we examine the tests made in 1875 and 1889 on the pulling power of a spike in Northern pine and in oak, we see that the improvements introduced in the ties of the screw spike and into the method of manufacture has increased their resistance about 30 per cent., or 7,640 lbs. against 5,733 lbs., and 12,844 lbs. against 9,922 lbs. in oak.

Finally, the method of fastening a flanged rail to wooden ties which we would recommend as a steel screw spike threaded hot, the pitch of whose thread is at least .5 in. for an outside diameter of .8 in., and of which the length, the diameter of the body and the projection of the thread shall be calculated so as to respectively offer a resistance to pulling proportioned to the kind of tie, and which shall be about the same as the tensile strength of the body of the spike itself. Then, this spike should be driven into a hole bored beforehand with a bit which is slightly less in diameter than that of the body of the spike. This hole could be advantageously reamed out for .08 in. or .1 in. at its upper end, in order to facilitate the entering of the body of the cylindrical portion of the spike into the wood.

THE OLDEST RAILWAY IN GERMANY.

A CORRESPONDENT, Dr. Justus Jehenhäuser, of Berlin, forwards us some interesting particulars concerning the Nuremberg Fürth Railway, the pioneer iron road of the Fatherland. The line, the first link in a chain of German railways of a total length to-day of 26,000 English miles, was opened on December 7, 1835, eight months having been occupied in its construction. Although the Liverpool & Manchester and Stockton & Darlington lines were in full operation when the project of thus connecting the two Bavarian towns was first mooted, the most absurd and superstitious objections were raised against the scheme; and one circumstance that greatly disturbed the equanimity of the frugal Germans was the demand of Robert Stephenson, whose services in the capacity of consulting engineer seem to have been retained by the promoters of the railway, for a salary of £800 a year for a mechanical general manager and his interpreter. This almost proved a knock-down blow for the project; but fortunately for the company, at this critical moment a Bavarian engineer, Herr Paul Denis, appeared on the scene fresh from the United States. Terms were evidently not a great consideration with this gentleman, for he was engaged on the spot, much to the discomfiture of the Englishman, who had been anticipating quietly dropping into a good berth in the lager-beer-making State. For economy's sake, Dr. Jehenhäuser informs us, the line, between the years 1835 and 1860 was worked in the forenoon with animal power, and in the afternoon with steam engines! Until 1847, in fact, the horse trains exceeded in number the locomotive trains. But in 1860 animal traction on the railway became a thing of the past. Reverting to the salary question, it should be noted that the Nuremberg Fürth line claims the rather dubious honor of being the only railway in the world that has paid more to an engine-driver than to its manager, the last-named functionary receiving, according to the expenditure account of 1840, £100 per year, the traffic-inspector £60, and a cashier at each terminus £40; while the Englishman, a nominee of Stephenson, who attended to the iron steed, eked out a merry existence upon an annual stipend of £125. Notwithstanding the competition engendered by the construction of a tramway between Nuremberg and Fürth in 1880, the railway company has continued to flourish, and last year it paid its usual dividend of 21 per cent., the receipts having been £15,800 and the expenses, £12,200. The reserve-fund already amounts to £66,600, while the share-capital, it seems, still remains at the original figure of £8,000. The present market value of the shares, we may add in conclusion, is a trifle over £50 each.—*Iron.*



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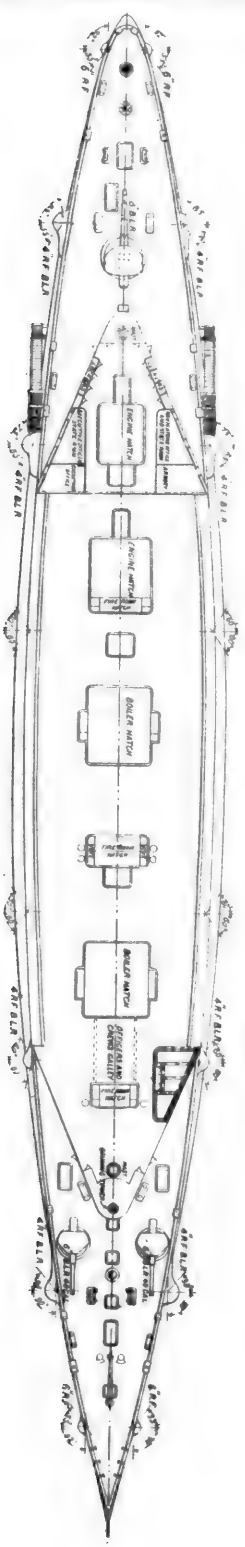
UNITED STATES CRUISER "MINNEAPOLIS."

THE United States cruiser *Minneapolis*, which is a sister ship of the *Columbia*, and has the same general appearance, with the exception of having but two smoke stacks instead of the four which the *Columbia* possesses, was launched from the Cramps' shipyard on Saturday afternoon, August 12. The vessel, which has been known in the Construction Department as Cruiser No. 13, is a commerce destroyer, and has been built in order to take the place in the United States Navy which the naval reserve in the shape of the fast transatlantic liners take in the navies of England, France and Germany. The general appearance of the vessel is very clearly given by the perspective side elevation on this page, for which we are indebted to Harper Brothers, by whom the cut has been copyrighted. The other engravings are made direct from drawings furnished by the Departments of Construction and Steam Engineering. The principal dimensions of the ship are: Length of water-line, 412 ft.; beam molded, 58 ft.; average draft with normal displacement, 26 ft. 6½ in.; displacement, 7,350 tons. The contract speed required will be 21 knots. The vessel is built of steel, and within the outer sheathing there is the second or double bottom, which is used to guard against injuries. The intervening space is divided into water-tight compartments.

The engines, boilers and magazines are protected by a heavy steel deck and 5 ft. of patent fuel extending along the sides in the region of the water-line and throughout the locality of the vitals, protecting the machinery, etc., from machine gun fire, and at the same time forming a reserve supply in case of the exhaustion of the regular coal allowance. The engines are three in number, each of the three-cylinder vertical inverted triple-expansion type, having a collective indicated H.P. of about 22,000, driving three screws—one in the middle line, as in a single screw ship, and the others under the two counters, as in twin screw vessels. At the time of launching the central screw was in position, while the twin screws under the counters will be put in position after the vessel is dry-docked. The general arrangement and inclination of the twin screw shafts is very clearly shown by the engravings. The power is calculated to produce a speed of 21 knots an hour under the usual trial conditions, which is guaranteed by the contractors. Each engine is in a separate water-tight compartment, the engines driving the twin screws being placed abreast, the same as in twin screw ships, and the one driving the center shaft is just abaft them, lapping each for one-half its width. Steam is supplied by eight four-furnace double-ender boilers, six of which are 15 ft. 6 in. in diameter by 21 ft. 3 in. in length, and which are 14 ft. 8 in. in diameter and 18 ft. 8½ in. long, together with two single-ender two-furnace auxiliary boilers 10 ft. 1⅜ in. in diameter by 8 ft. 6 in. in length. These boilers are now completed and are standing on the docks ready to be placed in position.

The full-page engraving which we present shows one-half of the largest size of these boilers. The corrugated furnaces are 3 ft. 4 in. inside diameter, with corrugations of 2 in., including the thickness of the metal. These furnaces were supplied by the Continental Iron Works of Brooklyn, N. Y.

The general construction of the boiler is clearly shown, and it is only necessary to call attention to one or two features which do not appear upon the engraving. The area through the slots which are shown in the top of the dry pipe is made equal to seven-eighths the area through the stop valve, which is



DECK PLAN OF THE UNITED STATES CRUISER "MINNEAPOLIS."

a 10-in. valve. The brass pipe is 10 in. in diameter and is made of metal No. 14 thick Birmingham wire gauge, and each course in the shell of the boiler is composed of three sheets, the metal being 1$\frac{11}{32}$ in. thick. The seams are butt riveted, the butt straps being 1$\frac{1}{32}$ in. thick. The rivets are so proportioned that the strength of the joint is that the plate has 84.6 per cent. of the strength of the undrilled plate, while the rivets have 89.5 per cent. of the strength of the same. The welt is riveted on with three rows of rivets. The first row stands back 2$\frac{1}{16}$ in. from the edge of the plate, and is staggered with the second row, which is set back 2$\frac{5}{16}$ in. from the first. The third row is staggered with the second, but has only half the number of rivets of each of the first two, and stands back 3$\frac{11}{32}$ in. from the second row. All these rivets are 1$\frac{5}{16}$ in. in diameter placed in holes drilled to the diameter of 1$\frac{3}{8}$ in.

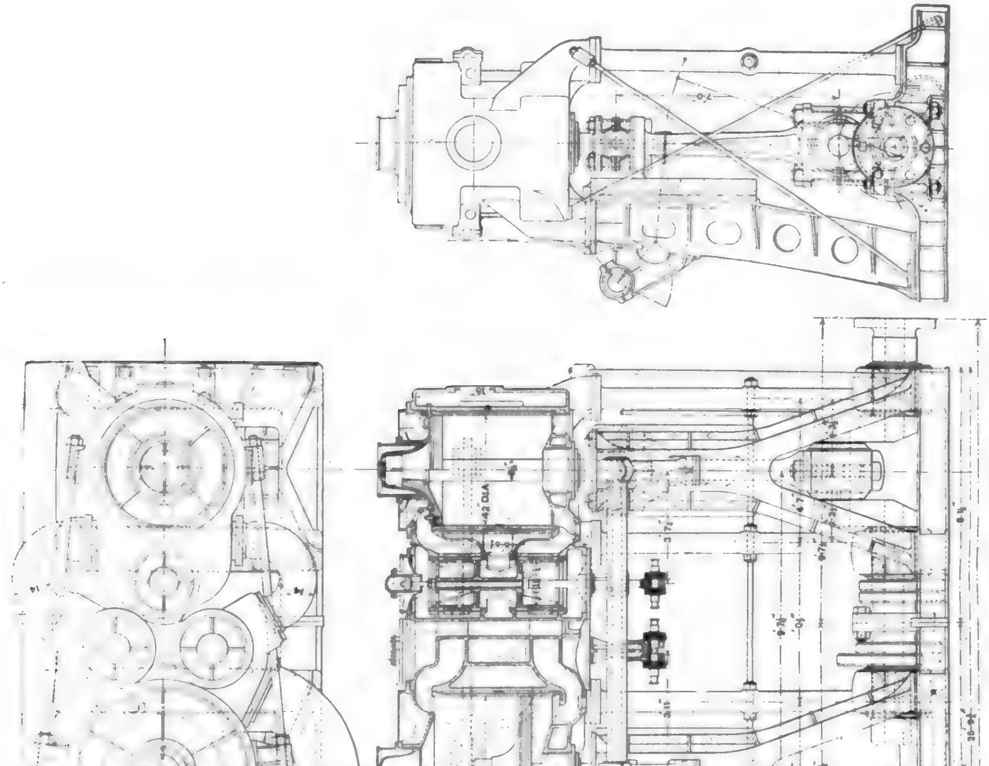
The general dimensions of the boiler are as follows: Diameter of boiler outside, 15 ft. 9 in.; diameter of furnace inside, 3 ft. 4 in.; length of grate, 7 ft.; heating surface in tubes, 5,539.5 sq. ft.; heating surface in furnace, 363.7 sq. ft.; heating surface in combustion chambers, 393.1 sq. ft.; total heating surface, 6,296.3 sq. ft.; grate area, 186.7 sq. ft.; ratio of heating surface to grate area, 33.7 to 1; calorimeter, 25.32 sq. ft.; ratio of grate area to calorimeter, 7.37 to 1.

The total number of tubes are 1,268; these are divided as follows: 316 stay tubes 6 Birmingham wire gauge thick; 952 ordinary tubes 12 Birmingham wire gauge thick. Working pressure, 160 lbs. The stay tubes are screwed into position, a practice which is followed by the Cramps in all of the large marine boilers which they construct. These tubes are screwed into both tube sheets. One end is slightly enlarged, so that the smaller end will pass through its hole readily. In order that the threads may be in unison, a special tapping bar is used in which the thread at the small end is tapped first, and then a guide thread runs through the thread thus cut in the tube sheet, and at the farther end of the bar a second tap is arranged, which is adjustable so that it will cut in unison with the thread at the small end. When the tubes are placed in position after starting at the small end the large end readily enters and the threads turn up together. The tubes are then beaded over in the ordinary way. The smaller tubes are simply put in position and expanded and beaded over. No ferrules are used; and it is stated that no difficulty has yet been experienced in keeping these tubes tight. The main stays which are shown over the top of the tubes are 2$\frac{3}{8}$ in in diameter and are screwed into the outer shells at either end, and held in addition by means of a heavy nut. The man-hole at the bottom between the bottom furnaces is 11 in. $\times$ 15 in. The same size is also given to the man-hole between the right-hand furnaces. The water leg between the furnaces at the back is 7 in. wide at the bottom, tapering up to a width of 10 in. at the top. This provides for an ample and free circulation of the water in the boiler. The tubes are 7 ft. 3$\frac{3}{8}$ in. long between the sheets; the location of the stay tubes is very clearly shown on the drawing, where they are shown of a thickness greater than those of the ordinary tubes. The outside diameter of all tubes is 2$\frac{1}{4}$ in.

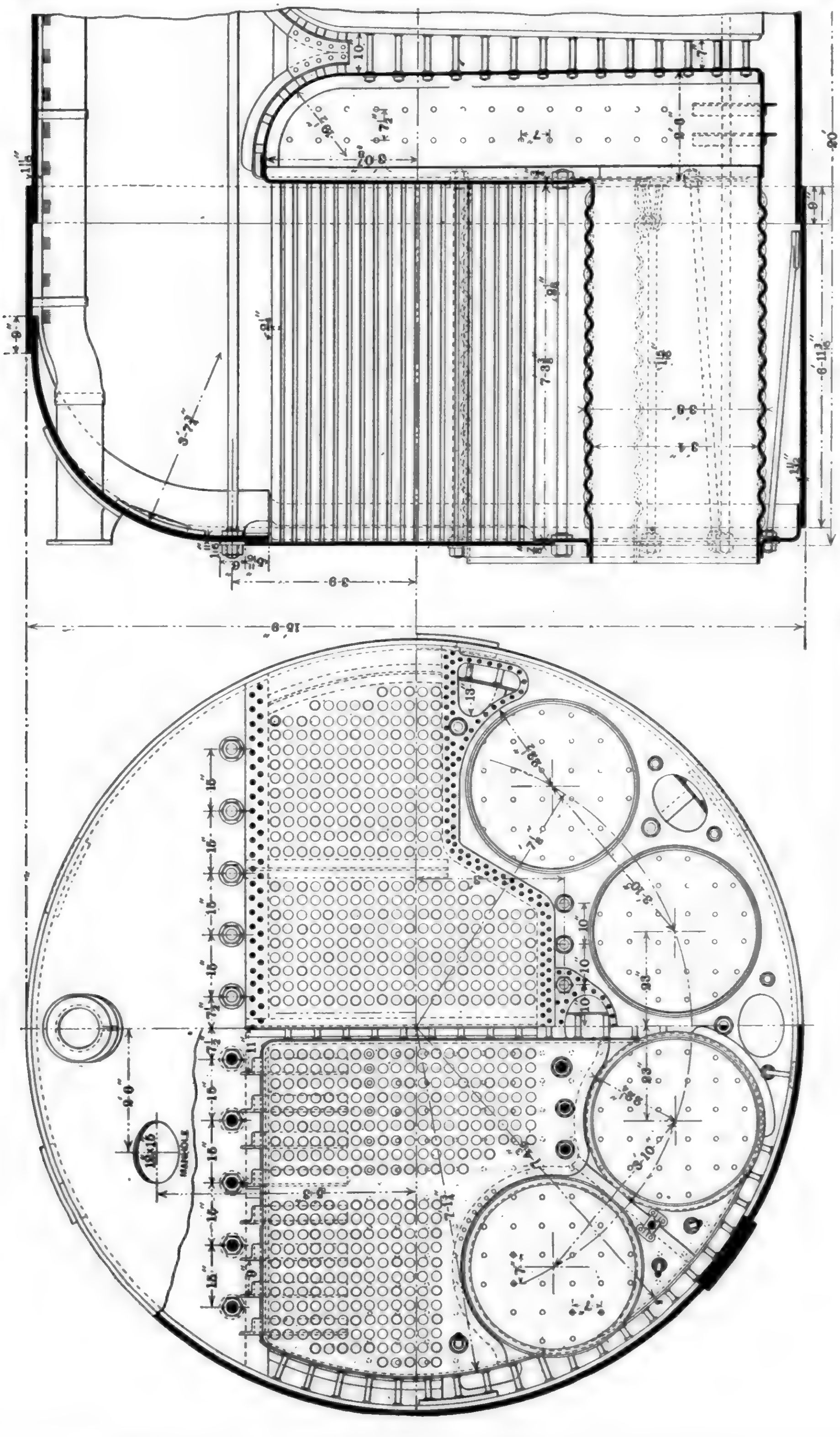
The cylinder dimensions of the engines are as follows: Diameter of high-pressure cylinder, 42 in.; diameter of intermediate cylinder, 59 in.; diameter of low-pressure cylinder, 92 in., with a uniform piston stroke of 42 in. The weight of all propelling machinery, including water in the boilers, is placed at 1,950 tons.

It is unnecessary to enter very fully into the details of the engine, of which a longitudinal section is given by our engravings. Attention is called, however, to the form of the pistons and cylinder heads, and especially to the high-pressure cylinder of 42 in. in diameter shown at the right of the engravings, in which the method of reducing the clearance space at the end of the stroke is very clearly shown. The other pistons will be seen to have the same methods of reducing this space, but they are not in position to show it as clearly with the high-pressure cylinder. The valves are piston valves.

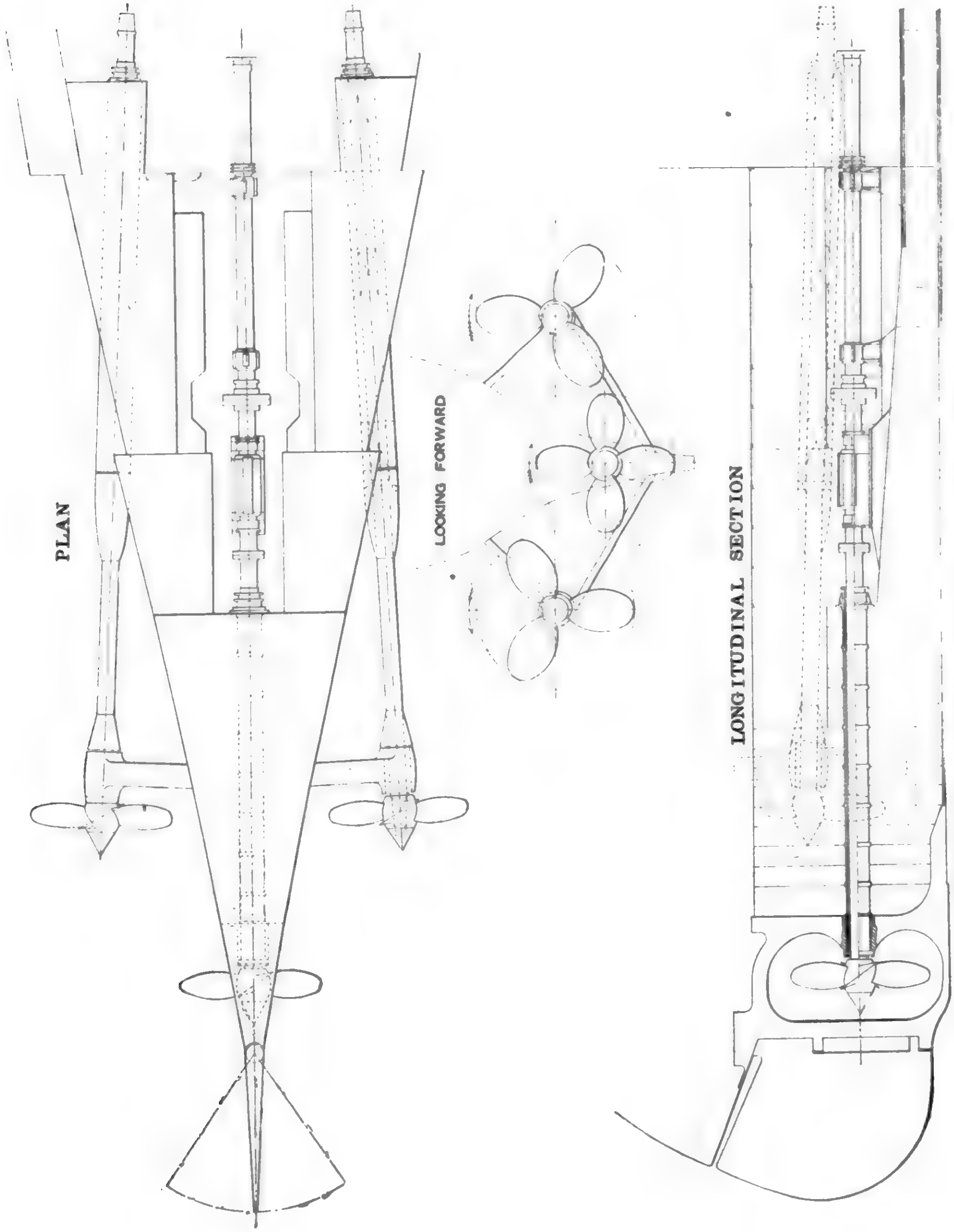
The coal supply on the normal displacement of the vessel is 1,200 tons, but there is a maximum bunker capacity of 2,200 tons, which, with an ample allowance for waste and non-effective consumption, will give the vessel, at the most economical cruising speed, a radius of action of about 16,000 knots. This is much less than the official calculation, but experience will demonstrate that it is approximately correct. The application of power through triple screws in large ships is an innovation, and its results in the *Columbia* are watched with intense interest by the entire civilized world. The *Columbia* has not yet had her trial trip, and the result of that trip will probably show about what may be expected from the *Minneapolis*. Essentially and avowedly a commerce destroyer and not a fighting ship, the armament of the *Minneapolis* is comparatively light. She carries one 8-in. breech-loading rifle of 40 calibre



STARBOARD ENGINE OF THE UNITED STATES CRUISER "MINNEAPOLIS."



BOILER FOR UNITED STATES CRUISER "MINNEAPOLIS."



SHAFTING AND PROPELLERS OF UNITED STATES CRUISER "MINNEAPOLIS."

a long aft, in the location shown on the deck plan ; two 6-in. breech-loading rifles on the rapid-fire principle, with shield protection on the upper deck, as is also shown on the plan. There are eight 4-in. rapid-fire guns on the main or berth deck, with 4 in. sponsons with a horizontal range of 140°. There is a slight variation, however, in the range forward and aft of the center line. The forward guns have a range of 90° forward or directly ahead, and 50° back ; the second guns have 80° forward and 60° back. The after guns have 85° back and 55° forward ; the second guns have 75° back and 65° forward. This range is clearly shown on the plan. The secondary battery consists of eight six-pounders and four one-pounder rapid-fire guns and four gatlings.

As we have already said, with the exception that the *Minneapolis* has two funnels instead of four, with hawser pipes open from the upper deck, she is exactly like the *Columbia*. The contract for construction was signed August 31, 1891, the price being $6,290,000.

The ceremonies of the launching on August 12 were made an occasion for quite a gala day. It was on Saturday afternoon, when there was a half holiday in the city, and it is probable that 20,000 people witnessed the launch. The ease with which the work was performed gives one but a very poor idea of what was actually accomplished. The vessel is, of course, light, and without her boilers or machinery ; but at the same time, to lower such a mass into the water quickly and safely is a task of no small magnitude. It requires about 500 men to do the work, and they were busily engaged most of the morning ; but after the work of driving wedges was first begun it was probably not more than three-quarters of an hour before the vessel was in the water. After the start was made and the christening performed, the vessel was anchored in the stream in about four minutes. In a future issue we hope to give a cross section and drawings of the methods which are employed by the Cramps for launching and handling these heavy vessels.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

IV.—METHOD OF DETERMINING SULPHUR IN STEEL.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page 393, Volume LXVII.*)

OPERATION.

Have ready the apparatus as shown in the cut. Weigh out 10 grams of the steel and put it into the evolution flask, which should be dry. Then put into the absorption U tube 50 c.c. of pure dilute hydrochloric acid, and connect this U tube with the evolution flask and put the bromine holder in place. Also connect the outlet of the bromine holder with the suction and then draw 5 c.c. of bromine from the holder into the U tube. Next pour 50 c.c. of distilled water through the bulb tube of the evolution flask, and start the suction a little. The displaced air passing through the U tube mixes the bromine with the liquid in the U tube. Now adjust the suction so that the column of water in the funnel tube of the evolution flask shall be about 1½ or 2 in. above the level of the water in this flask. Then add to the bulb tube of the evolution flask concentrated C. P. hydrochloric acid, at a rate sufficient to keep gas passing through the U tube, about three bubbles per second, until 100 c.c. of acid have been added. When this is done and the evolution of gas has begun to slacken a little, if the steel is not all dissolved, heat gently to assist solution, taking care not to increase the flow of gas above the prescribed rate. If solution is all complete by the time the acid is all in, or as soon as it is complete from the gentle heating, raise the temperature of the evolution flask to boiling, using the same precaution as above in regard to the flow of gas, and boil until the bubble tube between the evolution flask and U tube is about half full of condensed water. Then remove the lamp and put the permanganate of potash bubble tube in its place, and draw air through the apparatus at the prescribed rate for half an hour by increasing the suction. Then detach the U tube from the apparatus, pour the liquid in it into a 6-oz. beaker and wash the U tube carefully into the same beaker. Add also to the beaker the liquid in the bubble tube between the evolution flask and U tube, washing it out at least once. Now drive off all the bromine from the beaker by heat over the lamp or on the steam-table, taking care not to lose any of the liquid by too rapid ebullition ; neutralize the acid with ammonia in very slight excess, add hydrochloric acid to faint acid reaction, and then add three drops more of concentrated hydrochloric acid and 10 c.c. of chloride of barium solution. Boil a few seconds to granulate the precipitate, filter through a small paper filter, ignite wet and weigh.

APPARATUS AND REAGENTS.

The apparatus used in this method consists, as will be observed beginning at the left hand, of a bubble tube containing permanganate of potash to purify the air used in aspirating. This tube is detached from the apparatus during the evolution. Next is a 16-oz. flask fitted with a rubber stopper, carrying a bulb tube fitted with a glass stop-cock, and holding about 100 c.c., and an outlet tube. The bulb tube should reach so nearly to the bottom of the flask that the 50 c.c. of water should seal the end, and should have the bottom end drawn out and turned up to avoid the loss of gas, which would occur if the tube is straight and borings happen to be situated directly underneath it during the evolution. Connected with the outlet tube of the evolution flask is a bubble tube which at the start contains just enough distilled water to close the end of the tube inside, the object being to prevent bromine from diffusing back into the evolution flask. The outlet of this bubble tube is connected with the absorption U tube by rubber tubing. The absorption U tube is simply an enlarged U tube with bulb-like projections blown on the top of the transverse part of the U, to serve as pockets to retain the gas a little longer in contact with the absorbing liquid. This U tube is inclined, as shown in the cut, to facilitate the movement of the gases. To avoid a rubber cork, the tube which delivers the gas into the bromine solution is fused into the top of the inlet arm of the U tube. This delivery tube is drawn out at the lower end, so as to deliver small bubbles of gas, and is arranged so that the gases issue at the lowest point of the liquid in the U tube, in order to keep the bromine mixed with the acid. The transverse part of the absorption U tube is about 10 in. long over all, and has eight bulbular projections, and the vertical parts are about 8 in. high. The exit arm of the absorption U tube carries the bromine holder, which is fitted to it with a ground-glass joint. The bromine holder consists of three parts : 1. The ground-glass stopper to connect it with the absorption U tube, which stopper is hollow and is fitted with a tubular side opening to serve as outlet for the rejected gases ; 2. A bulb graduated to hold 5 c.c. for measuring the bromine, closed both at top and bottom with ground-glass cocks, and which connects between the upper cock and the graduating mark by a side tube with the top of part 3, in order to allow the measuring bulb to be filled without escape of bromine ; 3. A bulb holding about 25 c.c., closed with a glass stopper at top, which serves as a reservoir for storage of bromine. The three parts are, of course, connected with each other by tubes, so that there is a passage for the bromine. The outlet for rejected gases is simply a tube over which, when the apparatus is in use, is placed a larger tube in the form of an inverted U, which does not fit, and which is connected with the suction. With the apparatus as arranged the objections to working with bromine are almost entirely removed. The whole apparatus is mounted on a single stand, with two universal clamps, and is very compact.

The pure dilute hydrochloric acid is made by adding water to the concentrated acid until the specific gravity is 1.10.

The bromine is the commercial article obtained in the market.

The permanganate of potash solution is made by dissolving 10 grams of the dry salt in a liter of water, and adding 5 c.c. of concentrated C. P. sulphuric acid.

The concentrated hydrochloric acid and the ammonia are the ordinary C. P. materials.

The chloride of barium solution is made by adding 100 grams of the C. P. salt to one liter of distilled water.

CALCULATIONS.

Since the sulphur is 13.73 per cent. of the weight of the barium sulphate, if the weight obtained expressed in grams is multiplied by 13.73, and the product divided by 100, the quotient will be the sulphur expressed in grams. Then, since

the estimation is made on 10 grams, the percentage of sulphur in the steel will be shown by removing the gram decimal point one place to the right, thus:

If the weight of barium sulphate found is 0.0572 gram, the sulphur is $\left(\frac{0.0572 \times 13.73}{100}\right) = 0.0078$ gram, and the percentage of sulphur in the steel 0.078 per cent.

NOTES AND PRECAUTIONS.

This method, as will be seen, releases the sulphur from the steel in the form of sulphuretted hydrogen, oxidizes this gas to sulphuric acid by means of bromine, and precipitates and determines this acid as barium sulphate. Duplicate determinations can be made by the method as described in from three to three and one-half hours.

The use of bromine as oxidizing agent has this advantage over most other available substances for this purpose—viz., that it enables the precipitation with chloride of barium to be done in a solution practically free from solid salts. In view of the well-known tendency of barium sulphate to carry down other substances with it, this is a matter of some importance. The odor is, of course, objectionable, and it is almost impossible to get pure bromine, but these difficulties can be overcome, the former by the arrangement of the apparatus and the latter by proper allowance for the impurities.

It is essential before making a determination that not less than two blanks should be made, using all the chemicals in the prescribed amounts, and conducting the whole operation just as for a regular analysis, except that no steel is present. The weight of barium sulphate obtained as the result of these two determinations, which should not differ more than half a milligram, must be deducted from the weight of the barium sulphate obtained in the regular analysis of a steel.

It is very difficult to get bromine free from sulphates, and the C. P. hydrochloric acid of the market is also apt to be contaminated. It is accordingly recommended to set aside, for use in sulphur determinations only, a bottle of each of the chemicals used in making the blanks. Of course the figures obtained will be available as long as these bottles last.

All rubber tubes and corks used should be treated before use with a warm solution of caustic potash or soda, and after this the alkali must be completely removed by washing and the surfaces, especially the insides of the tubes, rubbed and cleaned until they present the appearance of rubber gum rather than of vulcanized rubber. Also the connections should be so made that as little as possible of the rubber tubing will be exposed to the evolved gases, by having the glass tubes at the joints touch each other inside the rubber tubing if possible.

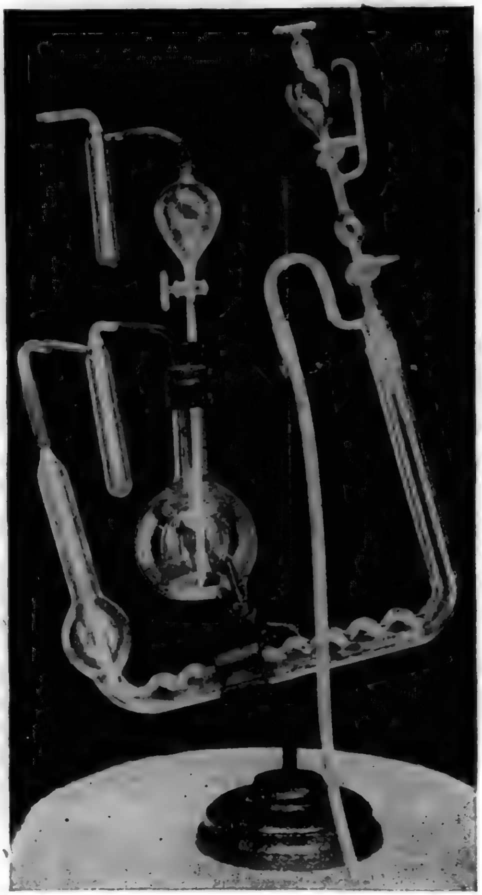
The use of a permanganate of potash bubble tube to prevent drawing sulphur gases into the apparatus along with the air used in aspiration is believed to be complete protection. Direct experiments with this solution show that both H_2S and SO_2 in air are completely retained by the permanganate of potash, even when the rate is three or four times as rapid as that specified above for the aspiration, and when the air before going into the permanganate of potash bubble tube was caused to pass through quite strong solutions of these gases in water.

Without the loose connection between the outlet for the rejected gases and the suction, it is quite difficult to regulate the rate of movement of the gases through the absorbing liquid on account of the varying rate of the escape of bromine from the solution during the operation. During the boiling to complete solution and expel the gas in the evolution flask, the rate of escape of bromine varies constantly, owing to rise in temperature. The suction being set at the beginning of the operation, if the bromine comes off a little more freely, a little less air is taken in at the loose connection and *vice versa*, so that, after the suction is once adjusted, it usually need not be changed again until the aspiration begins. We use for suction the same exhaust that is used for rapid filtration, and the bromine mixed with air that gets in through the loose connection passes away without annoyance. A large aspirator bottle filled with dilute caustic soda solution, and with inlet tube reaching nearly to the bottom, so that the rejected gases would bubble through the dilute soda solution, would be equally effective in managing rejected bromine.

It will be observed that there is no provision in the method as given for treating any sulphur compounds, which may remain undissolved in the evolution flask, as is essential in determining sulphur in pig iron. The reason for this is, that with probably 99 per cent. of commercial steels the material in the evolution flask is perfectly clear when the boiling and aspiration is finished. Furthermore, determinations on the same steel by the method given above and by the oxidation method, such as is used for pig irons, give concordant results. If the method, as described, shows a residue with any steel, the determination can hardly be regarded as satisfactory, and the oxidation method should be employed.

It is obvious that if the air of the Laboratory is contaminated with H_2S or SO_2, or even sulphuric acid fumes, from ignitions or evaporations, there will be danger of too high results from contamination of the liquid in the beaker from the two gases, while the bromine is being driven off, and at all time during the manipulation of the material in the open beaker from the sulphuric acid fumes. We have never proven how great this danger is, but it may possibly help to explain some anomalous results.

It is essential that the bulb tube through which the acid goes into the evolution flask should be left open, up to the time the permanganate of potash bubble tube is put in place, in order to prevent sucking back liquid from the absorption U tube. There is especial danger of this during the boiling.



APPARATUS FOR DETERMINING THE SULPHUR IN STEEL.

The acid may be added to the evolution flask little at a time, or may be put in the bulb tube and fed in through its glass stop-cock regularly. With some steels, and especially with coarse borings, all the acid may be put in at once and heat applied almost from the start.

When a large number of determinations are to be made at once, it is advantageous to add the barium chloride to the bromine solution in the beakers and put them on the steam table, and allow them to go to dryness; then add three drops of concentrated hydrochloric acid and about 25 c.c. of distilled water, heat nearly to boiling, filter, ignite and weigh.

Barium sulphate is liable to be reduced during the ignition of the filter, and thus lead to slightly low results. To obviate this difficulty, the filter and precipitate are put into the crucible wet, and the filter "smoked off" and then burned. The "smoking off" consists in applying the heat to the wet mate-

rial in the crucible so slowly that the volatile matter of the filter passes off without ignition, free access of air being maintained at the same time. To accomplish this, fold up the wet filter and place it in the crucible. Put the crucible on the triangle as in ordinary ignitions, and leave the cover off. Then heat the open end of the crucible slowly. The filter and precipitate gradually dry, and soon the parts of the filter in contact with the crucible begin to distill off the volatile matter at low heat, even before the whole is dry. This process goes on if the flame is properly adjusted, until in a little while everything that is volatile at a low temperature has passed away, and the precipitate, with a black envelope of carbonaceous matter, is left. When this is the case, the temperature can be raised, the lamp moved back to heat the bottom of the crucible, and the carbon burned off completely. Usually when the temperature is raised, the black envelope of carbonaceous matter falls away from the precipitate and is rapidly consumed. By this method of ignition the material is a little longer time in the crucible than with the old method of previously dried precipitates, but the danger of reducing the precipitate is believed to be very much diminished.

It is obvious that with the method, as described, no means are provided to tell whether any of the gas escapes oxidation in the bromine solution. It is believed, if the apparatus is arranged as described and the operation conducted according to the directions, no error will result. Careful comparative tests on the same steel, with the method as described, and the nitrate of silver method recommended by Fresenius, give strictly concordant results.

It will be noticed that air is used for aspiration instead of some inert gas, such as hydrogen, as is recommended by some. Comparative tests on the same steel with the method as described, and with the method modified by filling the apparatus with carbonic acid, and using the same gas for aspiration, gave exactly the same results. Carbonic acid was used instead of hydrogen as being more available.

(TO BE CONTINUED.)

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 398.*)

If there be one man, more than another, who deserves to succeed in flying through the air, that man is Mr. *Laurence Hargrave*, of Sydney, New South Wales. He has now constructed with his own hands no less than 18 flying machines of increasing size, all of which fly, and as a result of his many experiments (of which an account is about to be given) he now says, in a private letter to the writer, that : "I know that success is dead sure to come."

M. *Hargrave* takes out no patents for any of his aerial inventions, and he publishes from time to time full accounts of them, in order that a mutual interchange of ideas may take place with other inventors working in the same field, so as to expedite joint progress. He says : "Workers must root out the idea that by keeping the results of their labors to themselves a fortune will be assured to them. Patent fees are so much wasted money. The flying machine of the future will not be born fully fledged and capable of a flight for 1,000 miles or so. Like everything else it must be evolved gradually. The first difficulty is to get a thing that will fly at all. When this is made, a full description should be published as an aid to others. Excellence of design and workmanship will always defy competition."

M. *Hargrave* is probably correct in his reasoning, for the history of all new methods of transportation teaches that the original inventor seldom receives pecuniary reward for the contrivance which is the first to succeed, but nevertheless he is certainly broadly liberal in giving to the world gratuitously the results of his constant studies and labors. He uses exceeding care in determining the different elements which compose the flight of his models. He has carefully registered the sizes of all the parts, the power consumed in each performance, and the length of the flight, together with its trajectory. He states that he has always kept his work in such shape that it could be taken up and continued by any person at any time ; so that a stranger, if an expert, could come into his shop, study his notes and drawings, pick up his tools and continue his work, and thus no portion of it would be lost.

M. *Hargrave* reports regularly the progress of his work to the Royal Society of New South Wales, of which he is a member. Thus far 12 such papers have been published, the latest having been read August 3, 1892.

He first devoted his attention to the motions performed by the propelling surfaces of birds and fishes, the waves which these created in the fluids on which they acted, and the counteraction of these waves upon the forms of the propelling surfaces themselves. The first paper, therefore, presented in August, 1884, was on the *Trochoided plane*, which M. *Hargrave* defines as "a flat surface, the center of which moves at a uniform speed in a circle, the plane being kept normal to the surface of a trochoidal wave, having a period equal to the time occupied by the center of the plane in completing one revolution." This was illustrated by working models, and the motions of wings and of fishes in swimming were artificially reproduced.

Starting from these data, M. *Hargrave* next experimented with nearly 50 models intended to reproduce horizontal flight, and in exhibiting some of these and reading his second paper, June, 1885, he said : "If the motion is not that used by birds, it is at all events very like it, and its acceptance or rejection as a scientific truth is of no further interest, as it only remains for practical mechanics to step in and adjust the details to suit the material and the motive power which they may think best for the purpose they have in view ; or, in other words, that the solution of the problem of just how a bird flies is of very trifling importance from a practical standpoint, as compared with the judicious variations of the parts of the machine that will have to be made before any return can be expected for money invested in such undertakings."

Some of these models seem to have been driven by clockwork, and the motions were those of the "trochoided planes," as applied to flapping wings ; then selecting the best of these models, and making their mean dimensions a standard from which to take a fresh departure, M. *Hargrave* next built a series of experimental flying machines, actuated by india-rubber in tension.

The French experimenters, as we have seen, have preferred to use rubber in torsion in order to diminish the strains upon the central spine or backbone of the model, but they thus obtained less energy per pound of weight than if they had used it in tension. M. *Hargrave* stretched the rubber so that its elongation was multiplied by pulley-tackle, and that, as the rubber contracted, its center of gravity moved forward, thus advancing the center of gravity of the entire machine, and consequently diminishing the angle of flight as the force of the rubber decreased.

No less than 10 different flying machines of various types were thus built and experimented with, all moved by rubber in tension. In the first models the cord proceeding from the rubber was wound around a cylindrical drum on the crank-shaft, but owing to the variable resistance natural to a crank-shaft, it was found better to replace the cylindrical drum by a flat winder, so adjusted on the shaft that the moment of the cord varied with the resistance of the crank, and thus communicated a more uniform movement to the wings.

Seven of these machines seem to have been propelled by flapping wings—*i.e.*, "trochoided planes"—but in order that a comparison might be made, three varieties of models were made with screw propulsion—namely, with double and with single screws in the bow, and with a single screw in the stern, which latter was concluded to be the most practicable and serviceable form.

From these experiments M. *Hargrave* concluded that the screw and the flapping wings are about equally effective as instruments of propulsion, although he rather prefers the latter, as the wings possess several marked advantages. Any currents, he says, initiated during the up-stroke are utilized in giving increased efficiency to the down-stroke, if the machine has not progressed far enough to be acting upon entirely undisturbed air. Moreover, when steam-engines come to be used, there will be only one cylinder needed for both wings, there will be no conversion of reciprocating into rotary motion, and no variable listing moment to be counteracted, while, finally, there is less liability

that wings shall be damaged in alighting than screw blades.

Fig. 76 shows the last one (1889) of the india-rubber driven machines described by M. *Hargrave*. He calls it the "48 band-screw." The screw is at the stern, and the machine weighs exactly 2 lbs. Its sustaining area is 14.51 sq. ft. (7.26 sq. ft. per pound), and it flew 120 lineal feet with the expenditure of 196 foot-pounds of energy, while the preceding machine, weighing 2.09 lbs., with flapping wings, had flown 270 ft. with 470 foot-pounds, thus showing respectively 0.61 and 0.57 lineal feet flown per foot-pounds of power.

The framework of these machines was of pine, the larger piece (main spine) being a hollow box-girder, to secure strength and lightness. The sustaining surfaces were of paper, pasted on, and after the gum was dry rendered as tight as a drum by blowing a light spray of water over the

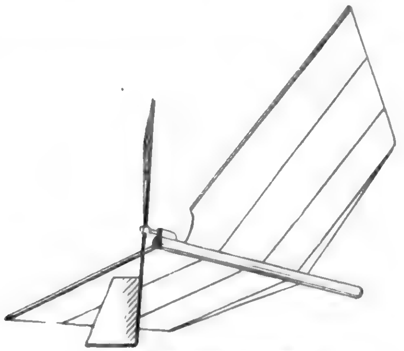


FIG. 76.—HARGRAVE - 1889.

paper and allowing it to dry. Thus with small, light, simple and inexpensive models many experiments were made, and great advance realized in the distance flown over any previous experiments of others.

Having progressed thus far with india-rubber as a motive power, and gathered most valuable data and experience as to the best arrangement and proportion of parts, the equipoise and the power required, M. *Hargrave* next undertook the construction of a flying machine actuated by compressed air, and, in 1890, he produced the machine illustrated by fig. 77, which he calls his "No. 10, 40.5 oz. compressed air," and which marked a very considerable advance in design by a great simplification of the propelling arrangement.

In presenting it to the Royal Society, June 4, 1890, M. *Hargrave* said :

The principle embodied in this experiment is that of Borelli, published in 1680, and it doubtless has had many stanch advocates in later times ; but the writer maintains that this is the first practical demonstration that a machine can and does fly by the simple (vertical) flapping of wings ; the feathering, tilting, twisting, trochoiding, or whatever it may be called, being solely effected by torsional stress on the wing arms.

The combination of Borelli's views with the results of work recorded in your proceedings (Royal Society) has swept away such a mass of tackle from the machine that its construction becomes a ridiculously simple matter. The engine of the model, of course, retains its precedence as the most important part, and by continuous effort the number of pieces and the difficulties of construction have been so reduced that it is possible to make them by the gross at a cost that cannot exceed five shillings each ($1.25). For instance, the cylinder, usually the most expensive portion of an engine, can be produced with the ease and celerity of a tin can. . . .

It might be said that this flying machine is not on the principle enunciated by Borelli, because the wings are not continuous from their tip to the body. But this arrangement is only a device to enable the wing tips to act on the required quantity of air with less spread ; it may possibly be one of those variations which make all the difference between success and failure. These wings are also distinctly double-acting, and it is not quite clear that birds' wings thrust during the upstroke ; but as previously stated, the question as to the exact movement of a bird's wing is merely straw-splitting, when we have a mechanism that actually flies and is manifestly imperfect in its present mechanical details.

This machine flew 368 ft., with the expenditure (as corrected by M. *Hargrave*) of 870 foot-pounds of energy. It weighed 2.53 lbs., and the sustaining body plane measured 14.78 sq. ft., while the two wings measured 1.50 sq. ft. in area, making a total of 16.28 sq. ft., or, say, 6.43 sq. ft. per pound.

London *Engineering*, in its issue of December 26, 1890, gives the following description of the machine :

The compressed air is stored in a tube which forms the backbone of the whole construction. This tube is 2 in. in diameter, 48¼ in. long, and has a capacity of 144.6 cub. in. Its weight is 19.5 oz., and the working pressure is 230 lbs. per square inch. The engine cylinder has a diameter of 1⅛ in. and a stroke of 1¼ in., while the total weight of the engine is only 6¼ oz. The piston-rod is made fast to the end of the backbone, and the cylinder moves up and down over the piston. Two links connect the cylinder to the Canadian red pine rods which carry the wings. The air is admitted to the cylinder and exhausted by means of a valve worked by tappets. The period of admission continues through the entire stroke. The cylinder and receiver ends are pressed, and the piston is made of vulcanite, with a leather cup ring for packing.

The wings are made of paper, and have no canting or feathering motion other than that due to the springing of the material of which they are made. The weight of the wings is 3 oz. To find how much the wings deflected, one was held by the butt and a weight of 7½ oz. was put on the membrane 24 in. from the fixed point, and 1⅜ in. abaft the wing arm. The deflection produced, due to torsional stress, was 3½°. By moving the weight half way across the wing it was twisted 8¼°. The area of the body is 2,128 sq. in.; the area of the wings 216 sq. in., and the total area 2,344 sq. in.

When first made, the machine had its center of gravity so placed that the percentage of area in advance of it was 30 per cent. of the whole area, but continued disaster caused its reduction to 23.3 per cent. In a dead calm the machine flew 368 ft. horizontally.

It will be noted that the engine is a marvel of simplicity and lightness. Its cylinder is made like a common tin can, the cylinder covers are cut from sheet tin and pressed into shape in a vice, the piston and junk-ring are made of vulcanite, and the cup leather packing does away with the necessity for the cylinder being either round or parallel.

Beside the engine, a marked advance consisted in securing the torsion of the wings through no special mechanism, as formerly, but simply by the elasticity of the material

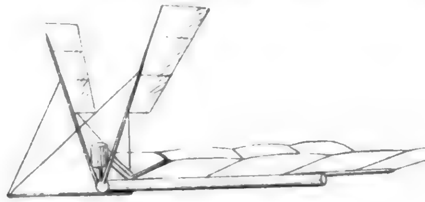


FIG. 77.—HARGRAVE, No. 10—1890.

composing them. This throws a new light upon the part performed in the flight of birds by the elasticity of their feathers, and promises great simplicity and efficiency in the future designing of artificial wings.

By looking at the figure, a bowsprit will be noticed. This was a so-called safety stick, which was added to break the fall of the machine when alighting, and it has proved quite successful in accomplishing that object.

A noticeable feature of this and subsequent machines exhibited by M. *Hargrave* consists in the extraordinary length of its supporting body plane. The same surface would carry a far greater load if it were driven broadside instead of lengthwise ; but M. *Hargrave* explains that the plane was purposely so designed in order to insure longitudinal stability. This quality might also be secured by placing a tail far in the rear of a narrow supporting plane, as practiced by *Pénaud* and others. He states, moreover, that the plane

is rendered more effective per unit of surface by being cut away in the middle portion, or by being formed in two parts, separated by a gap.

As regards the lateral equilibrium, he seems to have met with but little difficulty; a slight diedral angle of the two halves of the body plane with each other providing the necessary stability, and preventing any swerving so long as the center of gravity was at all below the center of effort; but he had great trouble in working out the longitudinal stability. This he did upon the "cut and try" principle—a method doubtless the most thorough, the surest, and the most convincing, but also the most tedious. He found that the direction up or down of the machines in flight was entirely due to the distance of the center of gravity from the forward edge of the body plane, and therefore to the coincidence or otherwise of the center of gravity with the center of pressure. He measured the percentage of area in advance of the center of gravity in his three most successful machines, and found it respectively 19.3, 20 and 23.3 per cent. of the length of the plane, while subsequently he came to the general conclusion that the true position for the center of gravity for a continuous rectangular surface is situated between 0.25 and 0.2 of the length from the forward end, these positions being arrived at "by experience gained by repeated wrecks when groping in comparative darkness."

This independent working out of a complex question well illustrates the perseverance and ingenuity of this experimenter. At this juncture, however, he would have been saved much groping, time, and annoyance had he been aware of the formula of Joessël for determining the center of pressure:

$$C = (0.2 + 0.3 \sin. a)\ L,$$

in which C is the distance from the forward edge of a rectangular plane to its center of pressure, when inclined at the

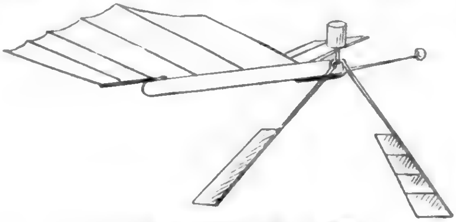


Fig. 78—HARGRAVE, No. 12.—1890.

angle of incidence a with the course, and L is the length of the plane along the line of motion.

In the same year (1890) M. *Hargrave* built another flying machine, actuated by compressed air and propelled by beating wings. This is shown by fig. 78. It was of the increased weight of 4.63 lbs., with sustaining body plane of different shape, measuring 29.63 sq. ft., or in the proportion of 6.40 sq. ft. per pound. It flew 343 ft., with an expenditure of 789 foot-pounds of energy, and therefore showed better results than the previous machine (No. 10), inasmuch as more pounds were transported on the air approximately the same distance, with a somewhat smaller expenditure of energy.

Having apparently found some advantage by shortening the body plane, M. *Hargrave* next built his flying machine No. 13, which is shown in fig. 79, with a body plane still shorter, and he provided it with a two-bladed aerial screw, set in the bow and actuated by a three-cylinder compressed-air engine of the Brotherhood type. This drove it 128 ft. in eight seconds, with an expenditure of 143 foot-pounds of energy. The apparatus weighed 46.86 oz. (2.93 lbs.), and exposed 2,952 sq. in., or 20.5 ft. of floating surface, being in the ratio of 7.00 sq. ft. per pound.

This is the first time (paper 10, July 1, 1891) that M. *Hargrave* gives us the time of flight of his machines, so that we may calculate the number of pounds of weight transported in ratio to the horse power. He says:

The time of flight is taken with a sandglass which has a loop of string at each end of it. The loop at the sand end is put round the right wrist, and the other loop is held between the right thumb and the receiver, so that the glass is turned the moment that the machine is let go. On the machine taking the ground the glass is put horizontal, and the sand which has fallen is timed at leisure. This seems an obvious enough method of finding the speed, but a practical way to do it was not devised previously.

This showed for No. 13 machine a speed of 10.34 miles per hour, which is about what we should have expected from the large proportional surface, it being about in the ratio of the slowest flying birds. This low speed M. *Hargrave* adopts on purpose, the better to observe the motions of the machines and to save breakage, and he adds quaintly that he sees no objection to this course, so long as the atmosphere is not crowded with flying machines. As No. 13 machine (fig. 79) is reported as having expended 143 foot-pounds in eight seconds, we have:

$$\text{Power} = 143 \div 8 = 18 \text{ foot-pounds per second,}$$

nearly, and, as it weighed (as reported) 2.93 lbs., we have for the weight sustained per horse power:

$$2.93 \times 550 \div 18 = 89.53 \text{ lbs. per horse power;}$$

while it will be recollected that M. *Tatin* sustained 110 lbs. per horse power and that M. *Phillips* in his recent (1893) experiments floated 72 lbs. per horse power. We will see by the analysis of subsequent performances that M. *Hargrave* did not obtain quite as good results with subsequent flying machines.

He next built his No. 14 flying machine, with much the same shape of body surface, but propelled by beating wings instead of a screw. It weighed 3.69 lbs. and exposed 22.84 sq. ft. of surface, being in the proportion of 6.19 sq. ft. per pound. It flew 312 ft. in 19 seconds, with an expenditure of 509 foot-pounds, and thus we have:

$$\text{Power} = 509 \div 19 = 26.79 \text{ foot-pounds per second,}$$

and for the weight floated per horse power:

$$3.69 \times 550 \div 26.79 = 75.75 \text{ lbs. per horse power.}$$

This apparatus (No. 14) M. *Hargrave* has generously offered to present to some American institution which will take proper care of it, believing it to be one in which "the increased skill in construction acquired by practice is thought to have resulted in an apparatus that, for its weight, it will be hard to excel." He says in his paper to the Royal Society:

It may be said that it is a waste of time to make machines of such small capabilities, and that no practical good can come of them. But we must not try too much at first; we must remember that all our inventions are but developments of crude ideas; that a commercially successful result in a practically unexplored field cannot possibly be got without an enormous amount of unremunerative work. It is the piled-up and recorded experience of many busy brains that has produced the luxurious travelling conveniences of to-day, which in no way astonish us, and there is no good reason for supposing that we

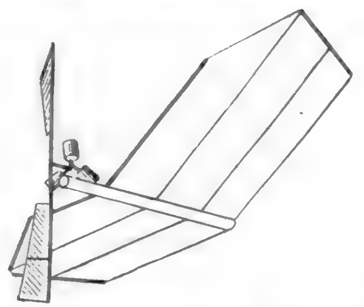


Fig. 79—HARGRAVE, No. 13.—1891.

shall always be content to keep on the agitated surface of the sea and air, when it is possible to travel in a superior plane, unimpeded by frictional disturbances.

No. 16 was another compressed-air flying machine with beating wings and somewhat differently shaped body plane. It weighed 4.66 lbs., spread 26.06 sq. ft. of surface, and

LOCOMOTIVE RETURNS FOR THE MONTH OF MAY, 1893.

Name of Road.	Number of Serviceable Locomotives on Road	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Av. Train. Passenger Cars.	Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Cost per Locomotive Mile. Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Cost per Car Mile. Passenger.	Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé	834	722	....	....	372,043	2,408,566	3,836	....	....	....	....	....	71.05	....	....	3.84	5.85	0.29	0.13	6.88	1.01	18.10	....	....	1.58
Canadian Pacific	612	....	518,921	737,933	438,052	1,689,806	2,761	....	....	....	....	....	65.12	....	....	4.07	10.50	0.34	....	5.69	1.42	22.02	....	....	3.21
Chic., Burlington & Quincy	542	....	....	....	....	1,759,662	3,265	5.23	18.04	....	....	....	83.86	....	....	4.74	5.56	0.24	0.16	6.93	0.07	17.71	....	....	1.33
Chic., Milwaukee & St. Paul	827	....	....	....	....	2,473,555	2,990	....	....	....	....	....	70.59	....	....	4.54	7.44	0.28	....	6.20	....	19.16	....	....	2.05
Chic., Rock Island & Pacific	564	....	616,453	931,108	448,136	1,997,697	3,542	....	....	58.08	78.67	41.23	64.06	....	....	5.70	5.96	0.27	....	5.95	0.41	15.44	....	....	2.00
Chicago & Northwestern	888	....	751,263	1,358,559	709,780	2,816,602	3,171	....	....	....	....	....	83.15	....	....	8.76	7.40	0.36	....	6.36	0.87	18.75	....	....	1.76
Cincinnati Southern	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cumberland & Penn.*	....	24	5,361	29,583	....	34,944	1,456	....	....	....	....	....	93.89	....	....	7.20	5.10	0.48	....	....	2.05	14.78	....	....	....
Delaware, Lackawanna & W. Main L.	210	191	66,970	206,955	449,380	723,305	3,787	....	....	....	....	....	85.57	....	....	3.22	6.65	0.47	....	5.75	....	16.09	....	....	1.57
Morris & Essex Division	160	....	176,796	159,951	99,610	436,358	2,727	....	....	....	....	....	59.22	....	....	4.50	9.29	0.43	....	6.23	....	20.45	....	....	3.11
Hannibal & St. Joseph	....	74	....	....	....	260,796	3,780	5.52	16.67	....	....	....	82.74	14.05	6.19	2.50	5.19	0.18	0.26	6.88	0.08	15.39	....	....	1.28
Kansas City, F. S. & Memphis	143	....	102,133	222,385	106,088	430,606	3,011	....	....	....	....	....	59.52	....	....	4.32	5.13	0.24	0.37	7.45	....	17.51	....	....	1.68
Kan. City, Mem. & Birm	42	38	36,793	40,401	16,306	93,500	2,513	....	....	....	....	....	61.10	....	....	4.27	3.24	0.24	0.36	7.16	....	15.27	....	....	1.01
Kan. City, St. Jo. & Council Bluffs	....	38	....	....	....	140,048	3,685	5.08	20.64	....	....	....	63.69	13.13	4.45	2.63	5.73	0.14	0.21	6.20	0.08	14.94	....	....	1.91
Lake Shore & Mich. Southern	587	....	458,536	788,765	480,740	1,828,041	3,114	....	....	60.08	84.24	39.56	62.93	....	....	3.14	4.93	0.06	0.13	6.96	0.19	15.41	....	....	2.01
Louisville & Nashville	....	838	454,319	797,140	434,879	1,687,338	3,626	5.13	15.99	61.64	106.55	47.97	78.65	12.14	6.14	4.55	6.32	0.27	1.32	6.06	0.61	19.15	3.41	1.51	1.66
Manhattan Elevated	....	295	796,169	....	60,815	856,984	2,905	....	....	....	....	....	43.95	....	....	2.90	8.90	0.20	....	8.90	....	20.90	....	....	4.03
Mexican Central	148	114	....	....	....	414,608	3,639	....	....	....	....	....	70.42	....	....	5.18	14.54	0.53	0.23	5.27	0.81	26.51	....	....	4.46
Mil., L. S. & Western	112	....	79,282	148,745	67,299	300,326	2,681	....	....	....	....	....	72.07	....	....	3.86	10.01	0.16	....	6.16	0.92	20.63	....	....	2.80
Minn., St. Paul & Sault Ste. Marie	....	....	65,065	156,620	68,365	290,050	....	5.98	18.64	....	....	....	68.75	....	....	4.40	11.80	0.28	....	6.46	....	22.94	....	....	3.42
Missouri Pacific	335	....	....	....	....	1,146,963	3,433	4.35	16.25	....	....	....	81.93	....	....	5.57	5.78	0.32	1.31	6.35	1.32	20.65	4.12	1.58	1.43
Mobile & Ohio	107	83	64,041	174,108	63,904	302,953	3,650	....	....	....	....	....	65.21	....	....	2.57	4.69	0.22	0.56	5.78	0.87	14.71	....	....	1.43
N. O. and Northwestern	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
N. Y., Lake Erie & Western	618	407	464,994	859,958	288,735	1,613,682	3,964	4.60	22.50	87.30	133.50	66.75	....	18.90	5.90	5.07	6.06	0.39	2.23	7.27	1.17	24.16	....	....	1.50
N. Y., Pennsylvania & Ohio	256	170	139,004	423,248	159,007	721,259	4,242	5.60	18.20	86.60	121.80	77.45	....	10.40	6.90	3.33	5.61	0.31	2.35	6.57	0.97	19.40	....	....	1.12
Norfolk & Western, Gen. East. Div.†	....	....	118,194	333,204	58,329	509,727	2,918	4.70	20.70	46.29	119.76	....	....	9.80	5.60	3.40	3.90	0.70	....	....	....	8.00	....	....	....
General Western Division†	....	....	103,058	308,257	45,510	456,820	2,532	5.40	17.10	69.00	126.00	....	115.00	13.26	7.98	6.71	4.29	0.51	....	....	....	11.51	....	....	....
Ohio and Mississippi	115	..	149,207	138,027	97,028	384,262	3,341	....	....	....	....	....	73.72	....	....	3.22	2.77	0.23	1.20	5.33	1.56	14.41	....	....	0.73
Old Colony	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Philadelphia & Reading	....	....	485,410	344,715	1,020,178	1,850,303	....	....	....	....	....	....	81.69	....	....	4.96	6.08	0.35	....	5.92	0.42	17.60	....	....	....
Southern Pacific, Pacific System	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Union Pacific	998	....	715,888	1,392,988	470,632	2,579,408	3,332	5.84	17.16	....	....	....	95.51	....	....	7.24	9.88	0.41	0.89	7.98	1.18	27.48	4.39	2.00	2.05
Vicksburg, S. & P.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Wabash	426	351	422,300	682,901	301,309	1,406,510	4,007	5.07	16.34	69.30	97.41	58.08	78.95	13.65	5.95	3.46	4.05	0.28	....	6.23	0.66	14.80	2.48	1.08	1.05
Wisconsin Central	138	122	139,708	203,067	73,249	406,088	3,328	....	....	....	....	....	80.97	....	....	3.29	8.34	0.32	....	6.96	....	18.77	....	....	2.03

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

flew 343 ft. in 23 seconds, with an expenditure of 742 foot-pounds. The power was therefore:

$$\text{Power} = 742 \div 23 = 32.26 \text{ foot-pounds per second,}$$

and the weight floated per horse power:

$$4.66 \times 550 \div 32.28 = 79.45 \text{ lbs. per horse power.}$$

Several forms of body plane seem to have been tested in this machine and no less than 12 trials were recorded, trial No. 10 being the successful one, from which the above data have been taken.

Having now constructed ten flying machines of different types and proportions actuated by india-rubber in tension, and six actuated by compressed air, of increasing size and weight, M. *Hargrave* then turned his attention to producing a steam motor which should equal in lightness and surpass in power the best compressed-air motors thus far constructed by him, and which should furnish driving power for a longer time.

But first he endeavored to work out an idea which he seems to have entertained for some years, of testing an explosion motor. His engine No. 15 consisted of a turbine to be worked by the gases resulting from the explosion of a mixture of nitrate of ammonia, charcoal, and sulphur; but a considerable expenditure of time only resulted in a failure.

He also experimented upon a method of utilizing sea waves in propelling vessels, which he believes to be the germ of the solution of the soaring problem, and he succeeded in securing such automatic action that a 12½ lb. model advanced in the wind's eye at five-eighths of a mile per hour.

He also made some experiments upon pure aluminium, but found that it presented no advantages for flying-machine construction.

(TO BE CONTINUED.)

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

The object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in July, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS FOR JULY.

Rowaton, Conn., July 1.—The cylinder-head of a locomotive hauling a train on the New York, New Haven & Hartford Road blew out this morning, severely scalding the fireman and delaying traffic for several hours. The fireman was taken to a hotel, where his wounds were attended to.

Wheeling, W. Va., July 4.—An accommodation train on the Panhandle Road was derailed this morning south of Wellsburg. The fireman of the engine, Simon Cussick, of Steubenville, O., was killed. Several passengers were injured. Spreading of the rails caused the disaster. The engine and two coaches were derailed and overturned.

Erie, Pa., July 8.—A head-end collision occurred between Philadelphia and Erie freight trains Nos. 65 and 62, near Johnsonburg, this morning. The west-bound train, No. 65, passed Ridgeway without orders. Engineer John Bradlock, of Renovo, on the east-bound special, was killed at his post. Fireman Keppler was also badly crushed and will die. Engineer J. Robinson, of the west bound train, and William Schoeffer, fireman, are severely injured.

Roanoke, Va., July 8.—William S. Arkins, fireman on the east-bound vestibule of the Norfolk & Western Railroad, fell from his engine this evening and was badly hurt.

Menominee, Mich., July 8.—In a wreck at Bagley to-night Engineer Berrington and Fireman Dolan were fatally injured.

Wilkesbarre, Pa., July 10.—James Finney, of Wilkesbarre, a fireman, was slightly hurt at Coxton to-night, by passenger train No. 17 on the Lehigh Valley Road running into a freight train.

Dover, N. H., July 11.—An extra train on the Boston & Maine Railroad collided with a freight car, which had backed off the Y at Rollingsford. Frank Down, engineer, and Forrest Carrish jumped. Carrish broke his neck, but was taken up alive and sent to Rochester, where no thoughts of his recovery are entertained.

Avon, N. Y., July 11.—Fred J. Barnard, a fireman on a way freight, fell from his engine when just out of Attica to-night and fractured his wrist.

Columbus, Ind., July 13.—A special freight train ran into a regular freight at Henryville, Ind., south of here to-night. George Sherley and Brook Bank, engineer and fireman of the special, were fatally hurt.

Chicago, Ill., July 14.—A Baltimore & Ohio suburban train was ditched at Eighty-seventh Street this morning. An open switch caused the accident. Engineer John Houlihan was scalded and painfully injured, but not fatally.

Radford, Va., July 15.—A collision on the new river division of the Norfolk & Western Road occurred to-day. Fireman Pool was killed, and Engineer Ransom badly scalded. Engineer Monroe had both ankles sprained and was hurt internally.

Pittsburg, Pa., July 15.—At four o'clock this morning engine No. 139, drawing the east-bound freight on the Pittsburg & Western Railway, ran into a mass of stone at the mouth of tunnel No. 1, near Undercliffe Station, completely wrecking the engine and six cars. Fireman John O'Neill and Engineer Charles Angell both sustained injuries in the accident, but not of a serious nature. The cause was the falling of the roof of the tunnel just as the train approached.

College Point, N. Y., July 17.—James Walsh slipped from the tank of his engine on the Central Hudson Road this morning, and fell to the ground, striking upon a large piece of coal, breaking two of the upper ribs on the left side.

Zanesville, O., July 18.—W. H. Core, an engineer on the Baltimore & Ohio Road, injured his right elbow by striking it against the backboard of his engine to-day.

Buffalo, N. Y., July 18.—An excursion train on the Western New York & Pennsylvania Railway ran into a turn table pit at East Aurora to-night. There was a sharp curve and down grade just above the station, and the engineer was unable to see that the switch leading to the table was open. Fireman John N. Norris received a concussion of the brain and a heavy cut over the left eye.

Scranton, Pa., July 18.—Matthew Whalen, of Great Bend, a fireman on the Delaware, Lackawanna & Western Railroad, was leaning out of the cab window this evening and lost his balance, falling to the ground. He was removed to the hospital, where it was found that several of his ribs were broken and that he had sustained internal injuries.

New London, Conn., July 19.—James Raleigh, fireman on the New London & Northern Railway, while turning an engine on the turn-table at Union Station, Norwich, this evening, caught his right forefinger between the turn-table lever and a car on the switch, badly crushing the finger.

Joliet, Ill., July 20.—A Rock Island & Pacific stock train ran into a side-tracked train at Tiskilwa this afternoon. George Hickey, fireman, and Henry Strong, the engineer, were killed. The flagman had been sent back, and states that Strong paid no attention to his signals.

Jackson, Mich., July 21.—Will Westfall, a fireman on the Michigan Central Road, was scalded by a stream of hot oil near Albion this evening. The glass of the lubricator burst, and three streams of oil were thrown out. One barely missed the engineer, another one went to the left side of the cab, while a third shot down upon Westfall just as he put the scoopful of coal in the fire box. The right side of the face and neck were badly burned; the skin was pulled off, leaving the bare flesh, from which the blood oozed trickling down his clothing. The young man suffered terribly on his way to Jackson.

Anna, Ill., July 21.—A south-bound train on the Mobile & Ohio Railroad ran into a loose freight car 2 miles west of Jonesburg to-day. The fireman, Joe Sammis, received internal injuries, and Engineer Ben Ward had his foot injured.

Cleveland, O., July 22.—An engine drawing three cars jumped the track in the Alabama Street yards early this morning. Engineer John H. Hines and his fireman leaped from the engine. The latter escaped, but Hines took the wrong side of the engine, and it toppled over on him. He was crushed and burned in a horrible manner, and was dead when extricated.

Danville, Ill., July 23.—William Burns, an engineer on the C. V. & C. Road, had his leg broken and head gashed in a rear-end collision at Lawrenceburg this morning. Burns was pulling the second section, and the first had stopped at Lawrenceburg for water, when Burns, thinking they had proceeded, came on. The collision occurred when the second section was moving at the rate of about 2 miles an hour, but Burns jumped and received the injuries specified.

Pittsburg, Pa., July 25.—An accommodation train on the Alleghany Road collided with a freight train at Willow Grove Station this morning. The accident occurred on a curve where the engineer of the approaching train was unable to see the freight train until too near to stop. Frank Stump, the fireman, jumped from the engine, and escaped with a few bruises. Engineer Albert Bissell stood at his post, and when taken out was found to have sustained only a few scratches and bruises, which will not prove serious.

Morgansville, Ky., July 25.—A freight train on the Ohio Valley Road was ditched 2 miles west of here early this morning. Robert Van Dorn, engineer, and Frank Threlkeld, the fireman, were killed and their bodies burnt to a crisp.

Warwick, N. Y., July 25.—Fireman Blake fell from his engine on the New York, Lehigh & Hudson Railroad near Maybrook to-night, and was seriously injured about the head.

Buffalo, N. Y., July 25.—Levi Snyder, a fireman on the Western New York & Pennsylvania Road, was badly injured this morning by a passenger train. He was tossed into the air and struck head-foremost upon the rails. When examined it was found that his skull was fractured, and he was otherwise badly bruised about the body and head.

Delaware, O., July 25.—In consequence of a misplaced switch a heavy coal train collided with a switch engine in the Hocking Valley yard at this place to-day. Engineer Brown, of the switcher, was terribly bruised and lacerated about the hands and face.

Nashville, Tenn., July 26.—Four cars loaded with logs became detached from a freight train about 70 miles south of here this morning, and ran back down a long grade into an express. Fireman Joe Zeanone was injured, but not fatally.

Wilkesbarre, Pa., July 27.—The Cannon-Ball freight train, on the Lehigh Valley Road, ran into a pusher at Gracedale this morning. The Cannon-Ball had two engines, one in front and one at the rear. Engineer George Hapeman, of the second engine, jumped and landed on a bank of dirt, rebounded against the engine, and sustained a severe scalp wound and bruises on his back. Martin Ryan, the fireman, had his arm badly hurt.

Pueblo, Col., July 27.—A cloud burst on the south side of Pike's Peak this morning, flooding the Arkansas River, by which the trestle on the Union Pacific Railroad, a mile from the city, was weakened, and a freight train plunged to the bottom of the cañon. Engineer Henderson lies under the engine, and Fireman Nye is fatally injured.

Reading, Pa., July 28.—A coal train pulling over the grade to Spring Mills on the Schuylkill Valley branch of the Pennsylvania Road broke in two this evening. Another freight train crashed into it. The locomotive was derailed and turned about. The engineer escaped injury by jumping, but the fireman, Frank Farrel, received a painful cut on the leg while attempting to stop the engine.

Indianapolis, Ind., July 28.—A passenger train on the Pittsburg, Cincinnati, Chicago & St. Louis Railroad collided with a freight train just north of this city on the Lake Erie & Western tracks. The collision was a head-on one. Al Woods, passenger engineer, had his ankle broken and face hurt. Walter Ensey, passenger fireman, had his face and head badly injured.

Springfield, Ont., July 29.—An express on the Michigan Central Road was derailed here this afternoon. The engineer was badly scalded.

Fort Worth, Tex., July 30.—Harry Lyons, an engineer at Celina, was terribly scalded to-day by the blowing out of a safety-valve.

Wilkesbarre, Pa., July 31.—An empty engine on the Delano Division of the Lehigh Valley Railroad ran into a passenger train near Mahanoy City to-day. Engineer Miner, of the passenger train, was injured about the head. Both engines were wrecked.

Our report for July, it will be seen, includes 35 accidents, in which seven engineers and nine firemen were killed, and 15 engineers and 19 firemen injured. The causes of the accidents may be classified as follows:

Blowing out of cylinder head	1
" " " safety-valve	1
Bursting of oil glass	1
Collisions	13
Derailments	4
Falling from engine	5
Misplaced switch	4
Striking against cab	1
Unknown	1
Tunnel roof falling	1
Struck against backboard	1
Turning engine	1
Struck by passing train	1
Washout	1
	36

GENERAL MARINE NOTES.

Largest Dredge in the World.—A trial was recently made of a large dredge built for deepening the bar at the mouth of the Mersey River. It is estimated that it will raise 24,000 tons of matter daily.

An Aluminum Cutter.—A 10-ton cutter constructed of aluminum, said to be the first sea-going vessel made of this metal, is being built at Loire, for Comte de Chabannes la Pollice. It will be half the weight of a vessel of similar class constructed with a steel frame. Her hull will weigh only 5,500 lbs., whereas, if built of the ordinary material, it would weigh 10,000 lbs.

The Battleship "Resolution."—The battleship *Resolution*, which has recently been completed on the Tyne, will take the place of the *Victoria*, which was recently lost. The new vessel is one of the largest battleships afloat, comprising one of the eight built under the Naval Defence Act of 1889. She is 40 ft. longer, 5 ft. broader, and has 3,680 tons more displacement than the *Victoria*. When used as a flagship she will have a complement of over 700 officers and men.

Air Sacks for Wrecking.—Air sacks have recently been successfully used for raising wrecks on the Pacific coast. The method consists of placing canvas sacks 20 ft. × 4½ ft. in the hold. Each of these sacks is attached by a hose to a powerful air-pump. The sacks are adjusted by a diver and are then inflated. Water is forced out of the hull, the inflated sacks taking its place and then acting as pontoons for raising the vessel.

A Bow Rudder.—The new steel side-wheel steamer *City of Alpena*, which was built at Detroit, is provided with a bow rudder that is used in moving the boat about the harbor. There are two wheels in the wheel-house, one operating the bow rudder by hand and the other connected with the steam steering-gear for the ordinary rudder. Considerable interest is manifested in the device among the vesselmen, and it is said to be working well.

The Largest Freight Steamer in the World.—A steamer which is claimed to be the largest freight steamer in the world has recently been launched at Dunbarton in Scotland. Her displacement is about 15,000 tons, and she will carry 7,000 tons of freight. In addition to freight she will have a capacity for 300 second-class and 1,200 third-class passengers, but no first-class. She is intended for traffic between Liverpool and Philadelphia, and is intended to make the distance between these two points in eight days.

Trolley System for Boats on the Colorado River.—We have noticed the fact that a trolley system of boat propulsion is to be tested on the Erie Canal, and recent advices from Colorado state that an investigation is being made as to the feasibility of using a trolley line for operating small boats through the Black Cañon and other scenic points. The power is to be generated by water-wheels driven by the current of the river. One of the features of the scheme is to convey the surplus portion of the power down the river, where it will be used for pumping the water of the river to a height of from 15 ft. to 20 ft. upon mesa lands for irrigation.

A New Idea in Ship-building.—The Boston *Journal* states that a new idea in ship-building has been developed at Belfast. There is a vessel on the stocks there which has no keel for about 120 ft. from the sternpost, while 6 ft. of the sternpost is cut away, the hull of the vessel sloping from the horizontal for the 120 ft. until level with the curtailed sternpost. The bottom of the sternpost and the actual stern of the vessel are not connected in any way. The vessel is a twin screw, and the propellers will work through a small aperture, with nothing between them and the water beneath. They will, therefore, always be in unbroken water.

Blowing up Derelicts.—A dispatch from Washington states that there is a probability of an agreement being made between England and the United States for blowing up the ocean derelicts. The proposition is that England and the United States shall each assign two warships of the cruiser type suited to this work, for the duty of keeping the tracks of ships and steamers in the North Atlantic clear of derelicts. The English ships will look after the wrecks on the adopted Transatlantic routes north, while the American ships will destroy the wrecks of the ocean farther south and along the coast between New York and Hatteras.

A Magnetized Towing Drum.—A novel application of electricity in the canal service has been made in France on the canals on which the endless chain system of towing is in vogue. The chain lies in the bottom of the canal, and is brought over the bows of the boats, carried around drums, and then passed over the stern into the water. In order to make the chain cling to the drums it has been necessary to pass it around them a number of times. This produces a heavy tension that results in frequent breaking of the chain. A drum magnetized with electricity has now been invented which holds the chain firmly and obviates the necessity of numerous turns.

A Kite to Send Life-lines Ashore.—Professor G. Woodbridge Davis has just concluded an interesting series of experiments with kites as a means of sending life-lines ashore at Newport, L. I. He went on board Brenton Reef lightship and remained there four days, and made the ship his headquarters for the experiments. He made several trials, but was unable to get suitable wind to land his kite on Brenton Reef, which is about 1¼ miles from the lightship. Failing to get a wind blowing on shore, Davis sent a kite out with a 32-lb. buoy as a drag. This was a success, and the five men engaged to haul the kite in declared the kite was not wet. The buoy was attached to a rope about 200 ft. from the kite, allowing the flying machine to float at that distance from the water.

A New Steamer for Fall River Line.—The new 4,000-ton steamer for the Fall River Line was recently launched at the old Roach shipyard, and was towed to New York the next day for the purpose of receiving her machinery. The new boat is 420 ft. on the water-line and 440 ft. over all, or 20 ft. longer than the *Puritan*. Her hull is 52 ft. 6 in. wide, and her extreme breadth over guards is 93 ft. The draft will be 12 ft. 6 in., and she has a total displacement of 4,550 tons. She was designed by George Pierce, Supervisor of the Fall River Line. Her outward appearance is similar to that of the *Puritan*. She has two steel masts and two smoke-stacks. Her passenger and freight capacity will be even greater than the *Puritan*, and she will be more elaborately finished and furnished. It is expected that she will be ready for service early next summer.

The British Mercantile Marine.—The total number of vessels in the British mercantile marine, say Lloyd's latest returns, is 21,542, with an aggregate tonnage of 12,203,761 tons. Of this number, 7,960 are steamers with 8,980,203 gross tons, or an average considerably over 1,000 tons each. Last year England added 872 vessels of 984,670 tons, of which 21,000 tons were purchased from foreigners. But England also sold to foreign nations, chiefly Norway, France and Germany, 117,000 tons more than she purchased. In the last six years nearly 4,500,000 tons of steamers have been added to the register, and only 1,600,000 tons have been removed; and of the latter the greatest number have only changed flags, and are still competitors for trade. In the same period 913,000 tons of sailing ships have been added on 1,206,000 tons removed; so that there are fewer sailing ships on the register now than in 1887.

An Amphibious Boat.—A new Canadian invention for use in the lumber districts is coming into general use in Northern Ontario. It is called a steam-warping tug. It propels itself on land as well as on water, and is used by lumbermen whose operations are carried on among small lakes connected by streams of uncertain navigation. The vessel has proved not only a success, but a great boon to the lumber trade. Six of these unique crafts have been built by the inventors during the past season, four completed at their yard and two shipped ready to be put together at their destination in the Nipissing district. They are built in scow shape, with steel-shod runners for moving overland; are 37 ft. long, 10 ft. beam, decked all over, and have sleeping room for four men in the bow; the bottom and up the bow is covered with steel boiler plate. An engine of 22 H.P. furnishes steam for 10 hours' work, with three-quarters of a cord of dry wood. In the water it moves six miles an hour forward or backward, as required, propelled by sidewheels. On land it is propelled by having a cable drum, on which is coiled five-eighths of a mile of steel wire cable, which is fastened with pulleys to a tree or some object in front, the boat moving as the wire is coiled up. The boiler is hung on an axle in the center, and a screw arranged on the front enables the fireman to tip it forward or back and keep it level going up or down hill. It will move over an elevation of 1 ft. in 3 on land, and draws about 28 in. in the water.

The "Bannockburn."—The *Bannockburn* is the name which will be given the new steel screw steamer recently constructed in the dockyards of Sir Raylton Dixon, Middlesborough, England, for the Montreal Transportation Company. The length of the vessel over all is 253 ft.; breadth, 40 ft.; molded depth, 21 ft. 3¾ in.; depth of hold, 18 ft. 7¾ in. Her dimensions are thus exactly adapted to the capacity of the Welland Canal. Although specially adapted for carrying freight, she will have first-class accommodation for a limited number of passengers. The saloon is situated in the after part of the vessel and will be handsomely furnished. The engines of the *Bannockburn* will be triple-expansion, having three cylinders of 21 in., 34 in., and 56 in. diameter, and a stroke of 39 in. She will have two boilers, each 39 ft. 9 in. long by 9 ft. 9 in. in diameter, tested to a working pressure of 160 lbs. to the square inch. The steamer will have five water-tight compartments, and provision is being made for ample water ballast tanks being fitted in the bottom, capable of carrying 750 gross tons of water. By this means the hull will be caused to sit deep enough when entirely light to be easily handled. She will be lighted by electricity and a good deal of the work aboard will be done by steam. The vessel is fitted with a steam steering apparatus. The *Bannockburn* arrived in Montreal about June 1. She will be taken apart and floated up the St. Lawrence to Kingston in sections. This vessel will be indeed an important addition to the large fleet of Upper Lake vessels and a credit to the enterprise of the company which she belongs.

The Simplex and the Huge Torpedo.—H. C. Vogt, Copenhagen, describes in *The Steamship* the Simplex and the Huge torpedo. Each of these is designed to carry a crew within a short distance of the object aimed at. The Simplex torpedo carries a single man who drops into the water in a particular dress or swimming apparatus, about 500 ft. from the ship to be destroyed. While in the torpedo, he occupies a hollow breakwater, strong enough to protect him from small shot. In outward appearance the Simplex torpedo resembles the Whitehead, and it is so small as compared with an ordinary torpedo boat that it is much harder to hit and much easier to manœuvre. It is intended to use petroleum for fuel and to bottle up the steam so that the man aboard can devote his entire attention to the helm and manœuvres. The Simplex was submitted to the United States Navy Department, which objected to it because of its dependence upon the boiler and machinery which must be left unattended during the time occupied in approaching the enemy, which may be for hours, and was then expected to develop its greatest power at the moment of attack. It was urged, too, that the change in trim at the critical moment of active service would cause a serious deflection in the course of the torpedo, and that the design was not sufficiently developed and reliable. In the Huge torpedo, the powerful spring releases a small boat about 600 ft. from the object of attack. This boat is protected by a small shield on the torpedo, and when launched is propelled by means of oars or by a screw with machinery similar to that of the Whitehead torpedo. It is expected to attain a speed of 1,700 ft. in a minute, and is exploded on impact by the crushing in of the bow and the ignition of kalium by the inrushing water.

Heavy Coal Consumption not Unprofitable.—The *Saturday Review* says that when a man talks of a fast boat, a 22-knot boat, which means a 25 mile boat from Queenstown to Sandy Hook, the pessimist utters the word "Coal!" and feels that no more terrible condemnation could be uttered. The coal consumption of the *Campania* is, no doubt, great; it has to feed 30,000 horses at full gallop for 2,800 knots; and the gallop will last about five days and a quarter; but, although this means over 2,500 tons of coal for the trip, the shorter trip means less human fuel in the shape of fewer meals for the passengers. The quick passage is all in favor of the ship-owner in the commissariat of the ship. Many of the passengers become hungry only on the fourth day, and the reduction of the journey from 10 to five days means something considerable in the consumption of beef, seeing that the reduction is always in the hungry days. The ship-owner calculates, with appalling indifference to suffering humanity, that if the passage could be shortened a day or two more, some of his pas-

sengers could be landed just at the time they were beginning to think about the cook as a person of consequence. There is another practical view of the case. A ship that can make a voyage to New York and back in a fortnight will earn 52 freights in the year, instead of the 26 of the boats of 20 years ago. The crew costs no more, if the coal does, and the earnings are double. But there is yet another view of the matter. The late Sir William Pearce, who began these fast boats by the building of the *Arizona*, and whose successors at Fairfield have built the *Campania*, once asked a friend, whose imagination reeled at the idea of a 22-knot boat, whether he would not prefer to go down in a fast boat in preference to meeting an ignominious death in an ocean tramp. The humor of the sentiment lies in the fact that it is the ocean tramp that always goes down in the case of a collision ; and it is the fast boat that sends the tramp down. Parliamentary humanitarians should see to this. Surely their reckless ingenuity is equal to the discovery of some way of preventing people from choosing their mode of drowning.

Steel Chords Broken.—The loss of the steamer *Western Reserve* on Lake Superior last season demonstrated the extent of the punishment that can be inflicted upon huge steel steamers by running them full tilt against heavy seas, and served the purpose of recommending wooden vessels to public favor, because of the impossibility of breaking them in two through similar usage. Nevertheless large wooden steamers suffer heavy punishment and are often brought to what might be styled the breaking point while being forced against head seas in light trim. This has been clearly demonstrated in the case of two of the largest wooden steamers of the Milwaukee fleet. One of these is the *Ferdinand Schlesinger*, which came out in 1891. She has a net measurement of 2,087 tons, and next to the *William H. Wolf* is one of the strongest boats of her class turned out from the old Wolf & Davidson yard. In addition to an abundance of diagonal strapping, two steel chords 18 in. wide and ⅝ in. thick, placed on the inside and outside of the heads of the frames and fastened together with through bolts, traverse the full length of the craft. During the two seasons she has been in commission the *Schlesinger* was on several occasions driven in the face of storms without cargo, and now it is discovered that on the port side, at a point about 50 ft. forward of the boilers, both of these heavy top chords have been fractured. The broken plates will be secured with laps. The second instance is presented by the steamer *Helena*, though not in so marked a degree. The *Helena* had an outer chord of steel 10 in. wide and ½ in. thick traversing the heads of her frames. On being stripped at the south yard, the other day, two laps of this chord, at a point about amidship on the port side, were found to have suffered a clean fracture. The chord has been removed, and hereafter the *Helena* will carry an inside and outside upper chord of steel 24 in. wide and ⅝ in. thick. Here are two marked cases of severe punishment to wooden steamers that have come to light because their owners have made no secret of the matter. There can be no question that numerous similar cases exist at other points along the lakes, and that the facts are kept carefully concealed from the public.—*The Evening Wisconsin.*

Visibility of Colored Lights.—The Lighthouse Board have recently been making some investigations regarding the intensity of lights used by the merchant marine as anchor and running lights. The method by which the observations were made were that three lights—a red, green and white—were located on the shore 25 ft. apart and about 15 ft. above water. Buoys were then placed at distances of 1, 2, 3, 4 and 5 miles from the shore station, ranged with the lights. A signal code was arranged by which the vessel from which the observations were made could signal as to whether the intensity of the light was to be increased or diminished. The experiments were begun about 8.45 in the evening. It appears from them that at 1 mile a white light of 1 candle power is clearly visible, while for red and green lights 3.2 candle power is fairly visible ; at 2 miles' distance a white light of 3 candle power is clearly visible, and red and green lights of 29 and 28½ respectively clearly visible ; at 3, 4 and 5 miles white lights of 3, 23 and 33 candle power are clearly visible.

The second series of experiments were made two weeks later, in which the committee attempted to determine the least candle power at which lights of different colors could be definitely seen at various distances, and it was found that this was not capable of a rigorous solution. In the first place, the eyesight of different observers varies, and a light of a certain candle power would be clearly visible to one while indistinct to another, and might be invisible to a third. Again, on different nights, apparently clear, the nature of the atmosphere, dry or humid, dusty or clean, would have a considerable influence on the range of the visibility of the lights. In cases of colored lights, red or green, the amount of absorption would increase with the density of the color of the glass, and this would also cause large variations in the range of visibility with lights of the same candle power behind it.

All of the above was taken into consideration by the committee in drawing its conclusion, and although the candle powers recommended are not the least that can possibly be seen in all cases, yet they are believed to be the least which can be used and still give a proper margin of safety. From the table which was prepared it is seen that for a white light the candle power recommended is 1, 2 and 30 for distances of 1, 2 and 5 miles respectively ; for red and green lights the candle power is 4 and 40 for 1 and 2 miles respectively.

The "Bonaventure," shown herewith (figs. 1 and 2), is a cruiser of a new type, lately launched from the dockyard at Devonport. She is built of steel, with bronze stem and stern posts, and the hull is wood-sheathed with 3½-in. teak and covered with copper. The length of the ship between perpendiculars is 320 ft. ; breadth, 49 ft. 6 in. ; and the normal displacement, with all her weight on board, will be 4,360 tons on a mean draft of water of 19 ft. Unlike the smaller cruisers recently constructed, the *Bonaventure* has a flush deck fore and aft, instead of a poop, forecastle, and waist. A distinctive feature of this cruiser is her steel protective deck extending right fore and aft, the forward part running down with a long sweep to the ram, of which it in reality forms a part. This

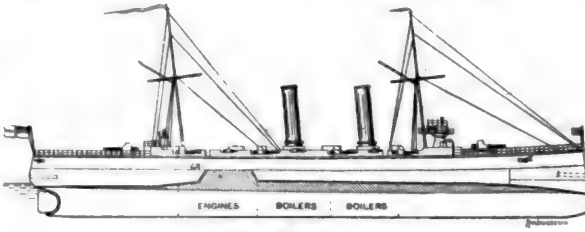
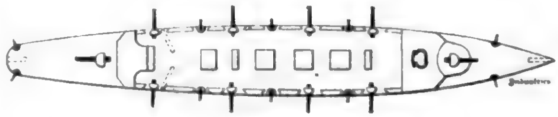


FIG. 1.—SIDE ELEVATION OF VESSEL.



NEW ENGLISH CRUISER "BONAVENTURE."

deck is arched transversely, so that at the sides of the vessel it is about 4 ft. below the normal load-water line, while at the centre of the ship it rises to a height of about 1 ft. above the water. It is composed of two layers of plating, measuring together 2 in. in thickness in the sloping parts amidships, and 1 in. in thickness on the flat part. Beneath this deck are situated the various magazines, and the propelling machinery and boilers. The propelling machinery consists of two sets of vertical triple-expansion engines to operate twin screws ; they are capable of developing collectively upward of 9,000 H.P. under forced draft, the resulting speed being estimated at 19.5 knots. Owing to the adoption of the vertical type of engine, the tops of the cylinders project above the level of the protective steel deck, and, in consequence, it has been found necessary to form an armored breastwork around the cylinders, the sides of which are built up of compound-steel armor plates, 5 in. thick, supported by steel **Z**-section bars. A double bottom extends throughout the engine, boiler, and forward magazine spaces, and in order to localize any damage which may occur to the hull, the vessel is divided into about 80 water-tight compartments, of which the hold proper contains 55. The heaviest guns carried will be two 6-in. quick-firing weapons, one mounted forward firing in a direct line ahead, and the other mounted aft with direct fire astern. In addition, there will be eight 4.7-in. quick-firing 36-pdr. guns, mounted four on each broadside. These guns are capable of firing about 12 shots per minute, and have a penetrative power equal to about 8 in. of iron. The auxiliary armament—if it may be so termed—will comprise ten quick-firing 6-pdr. Hotchkiss guns, and

four machine guns. There are also four torpedo-tubes, one fixed at the bow, another at the stern, and two others capable of being trained through a very large arc, situated one on either broadside.—*Industries.*

PROCEEDINGS OF SOCIETIES.

Association of Foremen Blacksmiths.—A call has been issued to the foremen blacksmiths of the United States for a meeting, which is to be held at Chicago on September 5, at 10 o'clock in the morning, at 109 of the Rookery Building, for the purpose of establishing a national organization for mutual benefit. Representatives from the mechanical press and iron and steel houses who may be interested in the matter are cordially invited to attend. The committee are: J. J. Thornton, C. H. Williams, W. J. Lottes and George F. Hinkens.

Engineering Society of Western Pennsylvania.—At a recent meeting Mr. E. D. Estrada presented a paper giving a complete account and analysis of experiments which he had made on the effect of suddenly applied loads upon the tensile strength and other physical properties of wrought iron and steel. The experiments described went to show that by a suddenly applied load elongation of these materials is very materially increased, and this occurred throughout the entire lot without a single exception.

The questions considered in the analysis of results were, Why does the elongation increase when the loads are suddenly applied, and why is the elastic limit in a like manner diminished? Will the sudden application of load diminish the load of a bar of iron or steel from that which would be developed had the load been gradually applied? When the same kind of material is tested in the screw, it is found that, although the elongation increases as the time diminishes, the resistance remains the same; therefore it seems reasonable to conclude that the elongation is a time effect, and that for two identical test pieces the resistance which would have to be overcome in both cases before fracture could occur would be the same, irrespective of the conditions under which the loads were applied, while the effects produced may differ.

OBITUARY.

John Stephenson.

JOHN STEPHENSON, the famous car-builder, died on July 31 at New Rochelle, N. Y., of old age. He was 84 years old, and had no particular ailment. Mr. Stephenson was born in County Armagh, Ireland, on July 4, 1809. The family settled in New York in 1811. After a course at the Wesleyan Seminary, this city, he was apprenticed to a coach-maker in Broome Street.

During the first two years of young Stephenson's apprenticeship to Andrew Wade, of 347 Broome Street, he spent his evenings drawing and designing. Abram Brower, a liveryman at 661 Broadway, the pioneer of the Broadway omnibus lines, had for four years run "accommodation vehicles" from the corner of Broadway and Bleecker Street to Wall Street, fare one shilling. His carriages were repaired at Andrew Wade's by young Stephenson.

In 1831, after his apprenticeship was completed, Mr. Brower invited Mr. Stephenson to open a shop at 667 Broadway. On May 1, 1831, Mr. Stephenson began business there on his own account. Then he designed the first vehicle known in New York as an "omnibus," which was quickly followed by the *Minerva*, the *Mentor*, the *Forget-me-not* and others. On the 29th of the following March his shop and all his stock were destroyed by fire. Then he started again at 264 Elizabeth Street.

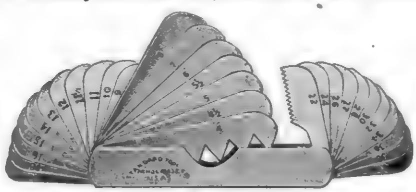
Mr. Stephenson had a growing omnibus trade, but the New York & Harlem Railroad, which was chartered on April 25, 1831, presented a new field for the exercise of his skill. This, the first of street railroads, confined by its charter to the corporate limits of the city, had for its president John Mason of the Chemical Bank. The business and passenger office was on the east side of the Bowery, two doors below Stanton Street. The company arranged with Mr. Stephenson to construct a car of entirely new design. The Stephenson car, *John Mason*, named after the president of the road, has become historical as the first street car ever used. On November 26, 1832, the road was opened from Prince Street to Fourteenth Street. On its first trip the car carried the Mayor and Common Council of the city. Mr. Stephenson received a patent on the car, now in possession of his family, signed by Andrew Jackson, President of the United States, and by members of his cabinet. Other orders from the same company followed, and in three years orders were received from Paterson, Brooklyn, Jamaica, N. Y., and from Cuba and Florida.

His business continued to extend, and his cars were sent to many foreign countries. The factory in East Twenty-seventh Street now employs 500 men. During the war he did good service, building many pontoons and gun carriages. Mr. Stephenson was regarded as a man of unflinching honesty, and at one time when he failed he refused to take advantage of the Bankruptcy Law, ultimately paying up every cent in full. About 27 years ago he made his home at "Clifford," New Rochelle. In 1833 he married Julia A. Tiemann. He leaves two sons and a daughter.

Manufactures.

NEW SCREW PITCH GAUGE.

WE illustrate a new screw pitch gauge which is just being brought out by the Standard Tool Company, of Athol, Mass., for determining all pitches in common use from 4 to 40 per inch, including those for pipe and brass work from 11½ in. to 27 per inch. The leaves are made narrow enough so that they will readily enter the nut, and can then be used for in-



NEW SCREW PITCH GAUGE.

ternal work. There is also a stop which prevents the leaf from opening beyond a line straight with the handle, which further facilitates its use for inside work. The larger pitches are so arranged that they can be used as a gauge for grinding tools.

AN ELECTRIC HEATER.

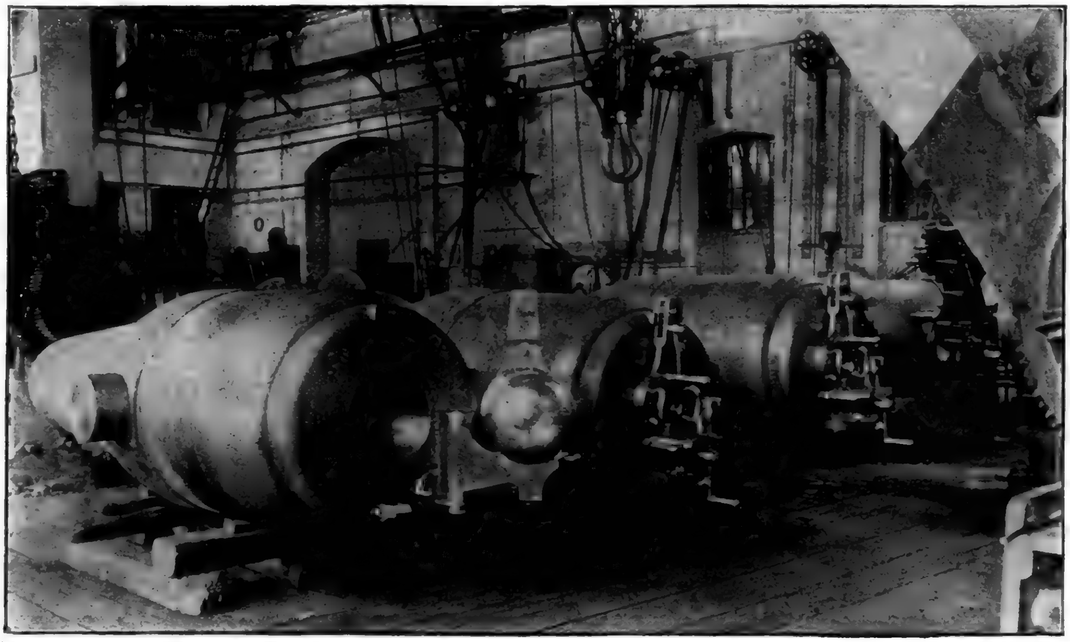
MESSRS. LAGRANGE & HOHO, two Belgian scientists, are the inventors of a new method of heating, melting and refining metals by means of electrical heat. The apparatus consists of a glass or porcelain vase of any size conveniently adapted to the purpose, provided with a lining of lead connected with a strong conductor of positive electricity. This is filled to three-fourths its capacity with acidified water. A pair of iron tongs with insulated handles is attached by a flexible conductor to the negative pole of an electrical current generated by an ordinary dynamo. The electrical current having been switched on, a bar of wrought iron or other metal is taken up with the tongs and plunged into the water within the vase. The water immediately begins to boil at the point of contact; the immersed portion of the iron rises quickly to a red, then to a white heat, and emits a stream of brilliant white light. The heat becomes so intense that the iron melts and falls off in bubbles and sparks, leaving a clear, glowing surface in perfect condition for welding. The heating process has been so rapid that neither the water nor the end of the bar held within the tongs have been more than slightly warmed. If instead of a bar of metal a stick of carbon is used, the heat in a few minutes produces detached fragments of amorphous carbon, which proves scientifically that a temperature of 40,000° Celsius has been developed. During the recent experiments at Berlin the measuring instruments registered a tension of 120 volts and an energy of 220 ampères.

It is as yet too early to form any definite estimate of the practical range or commercial value of this discovery.

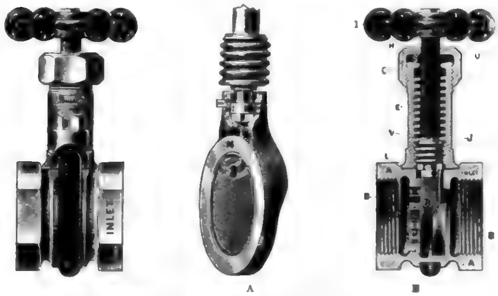
It has been applied to the welding of various metals with such success that it promises, in that special field, to inaugurate a complete revolution. The clean envelope of hydrogen which surrounds the heated metal prevents oxidation, and the welding surface is left free from the effects of sulphur and other impurities. It is believed that this may lead to important results in the hardening of and tempering of armor plates and other objects in iron and soft steel, in which great resistance to penetration or abrasion by friction is requisite, while preserving the interior tough and fibrous to resist concussion

or strain, as in many parts of machinery. At Essen Messrs. Krupp & Co. are experimenting with it in the hardening of steel cannon.

Whether it is applicable as an electrolytic process to the reduction of metals seems to be disputed. One account claims that by it the cost of refining gold, platinum, copper, nickel, and even iron will be reduced 80 per cent., while other authorities assert that, though metallic oxides may be successfully reduced by this method, no other foreign substances contained in the metal will be eliminated by it.



12-INCH BREECH LOADING RIFLE MORTARS, BUILT BY THE BUILDERS' IRON FOUNDRY.



THE "LUNKEN" GATE VALVE.

12-IN. BREECH-LOADING RIFLE MORTARS.

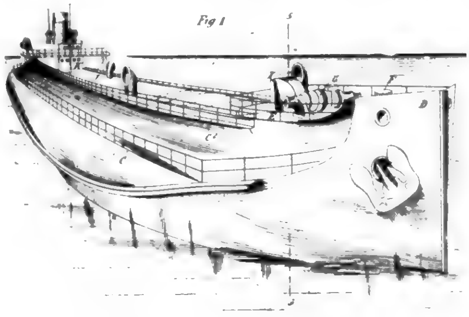
We present an engraving taken from a photograph of the 12-in. breech-loading rifle mortars built by the Builders' Iron Foundry, of Providence, R. I., and shown as they were laid out on the floor of the shop. These mortars are made with cast-iron bodies and two rows of steel hoops. The total length of the gun is 129.7 in., the diameter outside of the hoops being 42½ in. and weight 14½ gross tons, or 32,550 lbs. The guns are a part of the system of coast defense adopted by the United States Government in 1886, and 73 of them have been ordered at a cost of about $600,000. Their general appearance bears a close resemblance to the steel breech-loading rifles made by the Navy Department, with the exception of their length, which in the mortars is only 10 calibers instead of the 30 of the rifle.

The specifications call for the bodies to be made of charcoal iron, cast vertically breech downward and cooled by water circulation through the core on the Rodman process. Test specimens cut from both ends must have an elastic limit of 17,000 lbs. and a tensile strength of from 30,000 to 37,000 lbs. per square inch, or nearly double that of ordinary cast iron. The metal is melted in what is known as an air-furnace, and the iron, being separated from the fuel, is more uniform and homogeneous, and the results more reliable than can be obtained with the ordinary cupola. It takes about six hours to melt it, and then about two hours longer to bring it to a proper condition for pouring. The fuel consumed rises to about 37 per cent. of the weight of the metal. When the iron is tapped it flows through a long trough of fire clay directly from the furnace into the mould, and as soon as the piece is cast water is kept constantly circulating through the core and the cooling commences at once. The bore must be between 12 and 12.003 in. in diameter, and must be straight enough to allow a test cylinder 11.997 in. in diameter and 42 in. long to be slipped easily through its entire length. Sixty-eight grooves are cut in rifling, each 3.79 in. wide and .07 in. deep. These grooves have an increase pitch varying from one turn in 25 calibers to one in 40, the object being to avoid a too sudden initial rotation when the shot is fired. The steel projectile ordinarily used weighs 630 lbs. It is fired by a charge of 80 lbs. of brown prismatic powder, and at a distance of 6 miles will penetrate 4 in. of steel. It has a bursting charge of 30 lbs. of fine powder. As mounted, the gun can be fired about once in five minutes. It is proposed to distribute the mortars and mounts along the coast in groups of 16, and to have them shielded by earth embankments and fire them simultaneously by means of electricity.

THE "LUNKEN" GATE VALVE.

A new design of gate valve has recently been brought out by the Lunkenheimer Company, of Cincinnati, O., and we present illustrations of the same showing its general construction. The valve is available and intended for all pressures of steam or hydraulics which would be used or required in the workings of any plant.

The hub or bonnet is held to the shell by a coppered steel clip or strap surrounding the shell, with its end passing through the ears of the bonnet and secured by nuts *O*. This clip is held from lateral movement by projections on the shell. The joint is packed by a hard lead washer of $\frac{1}{16}$ in. thickness, the top faces of flanges each having a groove, to properly secure the washer. The valve can easily be taken apart without renewing the packing washer. The hub or bonnet is flat and narrow, and just of sufficient size to receive within it the valve disk when entirely raised, and has sectional or part-nut threads in its opposite interior sides. The threaded portion *J* of the stem by engaging with these part threads causes the valve to be opened or closed. The disk has a straight flat face or bearing against the renewable seat *C*, and is forced tightly against same by the self-adjusting wedging half-ring or horseshoe *D*, secured loosely in the valve shell. The wedging on the disk is applied on two wedging surfaces, diametrically opposite each other, these coming in contact with the beveled ends of the half-ring or horseshoe wedge; thus the wedging is properly equalized on the entire disk, and insures a tight joint on



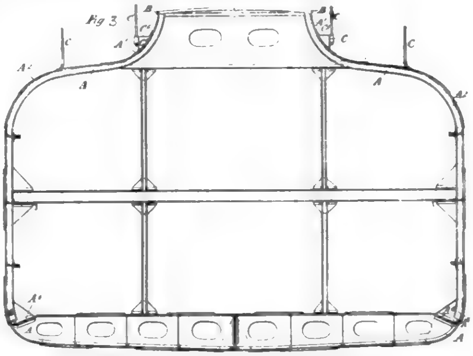
DOXFORD'S CARGO STEAMER.—BOW.

the opposite face. The pressure of the steam or liquid on the back or wedge side of disk also aids to make a tight closing valve. All valves above $2\frac{1}{2}$ in. size are provided with "by-pass," which arrangement balances the disk before opening same, and thus reduces the friction and wear on seat and disk to a minimum, and makes the valve open easily, regardless of what heavy pressure may be on same. The "by-pass," as shown in plate A and briefly explained, is an auxiliary valve formed in the top of the valve disk (immediately below the yoke that secures the same to the flanged head of the stem *H*),

DOXFORD'S CARGO STEAMER.—STERN.

and is operated by the stem of valve, automatically, while opening or closing the main valve. Channel *N*, passing through the disk, connects the inlet or pressure side of the valve with the outlet side, and the end of the stem *H* controls this channel, there being sufficient play in the disk coupling to allow the complete opening of channel *N*, caused by the first $\frac{1}{4}$ turn of the wheel in opening the valve. Plate E gives a sectional view of the main valve.

The renewable seat, it will be seen by referring to the cuts, is an exteriorly threaded flanged ring that screws against a face or shoulder of the flange, the opposite side of which flange forms the seat or bearing surface for the disk to close against. The inner periphery of the ring has lugs or teeth, *K*, for the engagement of the wrench, by which means the seat is operated, and either taken out or put in through the disk opening of the body without disturbing the pipe connections. In iron body valves the renewable seat *C* screws into a second brass ring permanently fastened in the iron shell, otherwise, owing to the rusting qualities of iron, the renewable seat might rust tight in the shell. The ring end *T* of wrench is used to hold and guide the removable seat into place, so as to properly start its threads into the threads in the shell.



DOXFORD'S CARGO STEAMER.—SECTION.

The valve is exhibited by the company at Chicago in Section 25, Column O, 24, together with a complete display of the specialties which they manufacture.

THE ARGENTINE GOVERNMENT VERSUS RAILWAYS.

A CORRESPONDENT in Buenos Ayres sends us some clippings from papers in that country containing editorial complaints that the Government in that country had taken ground that no more iron railway ties or sleepers should be admitted free of duty under the clauses of the concessions providing for immunity from import duties. This, it is claimed, is a violation of good faith, which is due to a mischievous and erroneous assumption that a railway is a public enemy, or at least a dangerous servant. One of the principal papers opposes the consolidation of the great Southern and the Western railways, because it fears the results of licensing such a powerful monopoly.

The management of railroads in that country does not seem to be faultless. The same correspondent says of some American cars that the doors forming part of vestibule arrangements have been either torn or taken off. Sleeping-cars built by some of the best manufacturers in this country are run in a disreputable fashion—one towel for a whole car full of passengers, no soap, no drinking water, and parties are allowed to keep up card playing, smoking, etc., in main compartments till 2 and 3 A.M., with lights going full head.

Sleeping-cars are execrable under the best management, but must be very objectionable indeed in Argentina.

Recent Patents.

DOXFORD'S CARGO STEAMER.

Figs. 1, 2 and 3 show a form of construction of cargo steamers for which patent No. 485,462 was recently issued to C. D. Doxford, of Sunderland, England.

This invention relates to the construction and arrangement of the hulls of vessels, particularly steam vessels adapted for cargo purposes. These vessels could be used for various kinds of cargoes, but are particularly applicable to cargoes—such as grain, coal, oil and the like—which are more or less liable to shift and which are carried in bulk.

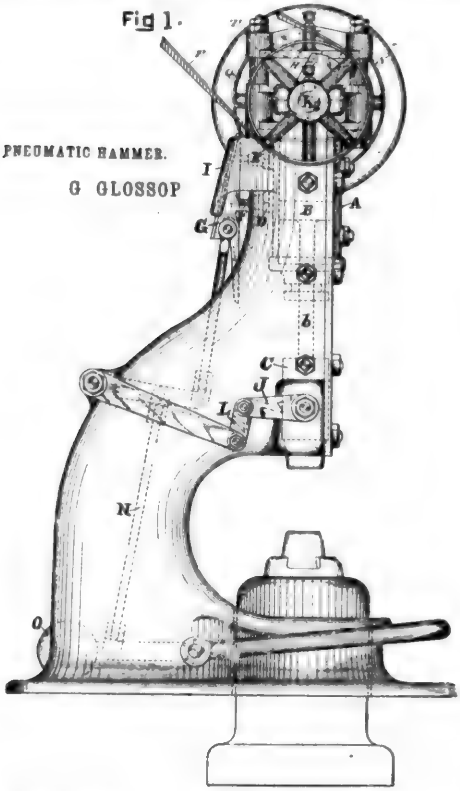
In carrying this invention into practice the ordinary deck is dispensed with and the sides curved inward with a convex curve for a suitable distance—say, for example, one third of

the total width at each side—and then upward with a concave curve, the top of these last curves reaching to the hatchway combings or the platform deck, in which the hatches would be formed. The above would represent the shape of the plates and framings amidships (the latter being carried continuously up as far as the plates) and these would be carried fore and aft without material variation for the greater part of the length of the vessel, merging at each end into a bow and stern of substantially ordinary construction. The hatchway extends over practically the whole length of the hold or cargo space, and may be closed by entirely independent covers, or these may be hinged or otherwise suitably connected and provided with permanent fastenings or arranged to be bolted down after each removal. The sides of the hatchway may be stayed across in any suitable manner, as by simple stays or by portions of fixed plating between some of the covers.

The engine and boiler rooms, coal-bunkers, cabins and offices may be located at the stern end of the vessel, behind the cargo-space, or amidships, and the quarters for the officers and crew either at the bow or stern, according to circumstances. The bows need not be carried up much higher than the before-mentioned hatchway combings or platform deck and would be left for the most part clear of incumbrances beyond possibly the warping-capstan, the windlass and the entrance to the forecastle or men's quarters, to protect which and generally to raise the height of the bows the forward plates may be carried up to a suitable level.

In the accompanying drawings, fig. 1 is a perspective view of a vessel constructed according to this invention taken from in front of the starboard bow. Fig. 2 is a similar view taken from the stern, and fig. 3 is a vertical midships cross-section showing the arrangement of the frames and plates.

Fig 1.



GLOSSOP'S PNEUMATIC HAMMER.

The drawings given herewith show a power hammer for which patent No. 485,498 was recently issued to Gilbert Glossop, of Sheffield, England. It is of the class generally known as pneumatic hammers. Fig. 1 is a side elevation of a complete hammer; fig. 2 is a central vertical section through the cylinder, showing the valves and movable pressure piece; and fig. 3 is a detail view of the mechanism for reciprocating the cylinder, taken at right angles to fig. 1.

The drawings show generally the construction of the hammer, and are, perhaps, best explained by the inventor's own account of the operation of the device, which is as follows: "When the outlet-valve H is held closed and the outlet-valve F is opened wide, no air can escape from the cylinder except through the middle port. When the upper end of the cylinder and the piston are moving toward each other, all the air between the valve F and the upper end of the cylinder is imprisoned, and when this air is sufficiently compressed the downward movement of the cylinder is transmitted to the piston and it is moved downward; and under this condition of affairs it is moved downward farther and with greater force than when there is a smaller quantity of air imprisoned between the piston and upper end of the cylinder. Another reason exists why the piston moves downward farthest and with greatest force when the valves are in the described condition—viz., only so much air as is between the valve F and the lower end of the cylinder is imprisoned between said lower end and the piston when the piston passes said valve in its downward movement. Therefore the piston meets with less resistance to its downward movement than it does where there is a greater quantity of air imprisoned in said lower end. When the valve H is permitted to open with greater freedom and the valve F is only partially opened, much of the air in the cylinder escapes through the upper port when the piston is moving upward in the cylinder, and therefore less air is imprisoned in said upper end, and it is not entirely imprisoned until the piston passes above the upper port. For this reason the piston will not be moved down with as much force as under the conditions first explained. At the same time the air cannot escape so freely through the port E, wherefore more air is imprisoned

Fig 2.

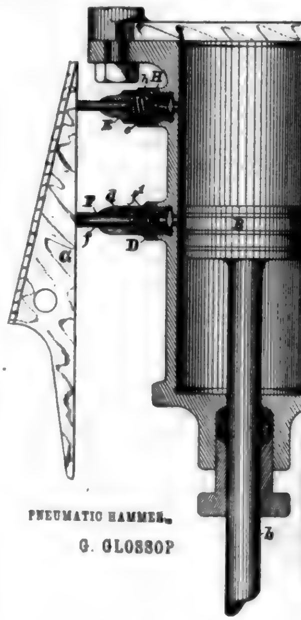
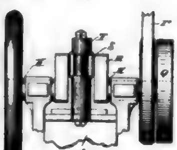


Fig. 3



in the lower end of the cylinder, and this offers a greater resistance to said downward movement. In the first case a heavy blow may be delivered by the hammer-head close to the anvil. In the latter case a light blow may be delivered a considerable distance above the anvil. The force of the blow and the point at which it is most effectively delivered may be varied to almost any degree between the two extremes above described by varying the relative openings of the two valves through the movement of the wedge-shaped pressure-block G. In small hammers, when a very considerable variation in the force of the blow is not required, the upper valve may be omitted altogether, leaving simply an open port, and the variation in the blow would then result wholly from the difference produced by the operation of the middle valve in the air cushion below the piston, which resists its downward movement."

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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NEW YORK, OCTOBER, 1893.

ANNOUNCEMENT.

WITH this number of the AMERICAN ENGINEER AND RAILROAD JOURNAL we will send to each of its subscribers a copy of the first issue of "AERONAUTICS," a new publication which will hereafter be issued monthly by the publisher of the AMERICAN ENGINEER. The *raison d'être* of this new periodical is explained in the "announcement" on its second page.

Hereafter all articles pertaining to the subject of aeronautics will appear in the paper with that name, excepting those on "Progress in Flying Machines," by Mr. Chanute, which will be completed in an early number of the AMERICAN ENGINEER, and will then be issued in book form.

The 12 numbers of AERONAUTICS, referred to in its announcement, will be furnished to subscribers to the AMERICAN ENGINEER in this country for 50 cents, and to all other persons in this country for $1. Twenty cents more will be charged to foreign subscribers. A blank order for AERONAUTICS will be found enclosed with this paper, which may be filled up, and forwarded, either with or without a remittance, to M. N. Forney, 47 Cedar Street, New York.

EDITORIAL NOTES.

IN April last we began the publication of the list of accidents happening to locomotive engineers and firemen throughout the country, and for each month it is truly sickening and appalling. We have, therefore, now published these accidents for seven months, and in that time nine men have been more or less severely injured by being struck by stationary objects placed too near the tracks. Certainly this is a class that can be truly characterized as an *avoidable* accident. Every company has a rule in which it is forbidden to locate any obstruction within a shorter distance than one regularly specified. This is ordinarily put at 5 ft., though we believe it to be too close. For when a man is leaning well out of the window to watch the side rods his head is apt to come pretty close to the 5-ft. limit from the rail; but when signal posts or the temporary work used in the construction of bridges or buildings is allowed to stand so near the track as to strike an engineman while in the discharge of his duties, the some one who is responsible for allowing such a state of affairs to exist should be held strictly and criminally responsible. In our preface to our monthly publication of these accidents, we say that it is done with a hope that it will "indicate some of the causes of accidents of this kind, and the causes or cures for any kind of accidents which occur." Surely the cure for this kind is easily discovered and just as easily applied.

AFTER the struggle to obtain an armor-piercing shot and a shot-resisting armor, the latest device for naval warfare is an invisible torpedo-boat—not a boat that follows the course of Captain Nemo's craft, but a vessel that floats upon the surface and protects herself by generating a cloud of smoke, so that her actual location is concealed from the enemy. Experiments have been made with this end in view for some time, but it is not until recently that anything approaching success has been achieved. Recent work, however, at Brest would seem to indicate that the Oriolle process promises to be very successful, and if it is, an entirely new element will be introduced into naval warfare.

THE reports in the foreign technical press show that for the next year there will be what might be called a renewed activity in naval construction. France will probably authorize the building of two battleships, and the English plans are arranged for two battleships and two cruisers. The work on the United States Navy also continues to be pushed, though it is not probable that there will be a launching of another large vessel before some time during the coming summer. Germany and Italy, however, seem to be doing less than England or France. Work is also progressing rapidly at the Cramp's shipyard on the new vessels for the American Line, which will form a nucleus for the new auxiliary navy which we all hope to see thrive and prosper.

LAST month saw the reopening of the meetings of several of the railroad clubs which have come to be a feature in so many parts of the country. Their growth and the large attendance at the majority of the meetings show that railroad men appreciate the opportunities which they offer, and are ready to take advantage of them. An objection has, however, been raised to some of them, that the meetings are held during the day rather than in the evening. It certainly seems as though the evening was the proper time for such gatherings, in that the local members are not taken away from their duties, while visitors or out-of-town members have the day available for travelling or visiting shops and an occupation for the evening, when time is apt to hang heavily upon their hands if there is no other employment available than that offered by the reading-room of a hotel.

COMPLAINT OF INSUFFICIENT TRAINS ON THE NEW YORK ELEVATED RAILROADS.

THE daily papers in New York now have frequent complaints, both from the editors and correspondents, of the insufficient accommodations furnished by the Elevated Railroads for the passengers who want to be carried. The law makes it the duty of the Board of Railroad Commissioners to "keep informed as to the manner in which the railroads of the State are operated for the accommodation of the public," and if "any addition to the rolling stock or in the mode of operating the road or conducting its business is reasonable and expedi-

ent, in order to promote the security, convenience, and accommodation of the public, the Board shall give notice and information in writing to the corporation of the improvements and changes which they deem proper. . . . It shall be the duty of the corporation, person, or persons owning or operating the railroad to comply with such decisions and recommendations of the Board as are just and reasonable. If it fails to do so the Board shall present the facts in the case to the Attorney-General for his consideration and action, and shall also report them in its annual or in a special report to the Legislature."

It would be interesting to know first whether the Board "keeps informed" as to the manner in which the Elevated Roads are operated and accommodate the public, and if not, why not? and if it is informed whether, in the judgment of the Board, the "accommodations" afforded between the hours of 7 and 10 A.M. and 5 and 6.30 P.M. are "reasonable." If they are "informed" and do think they are "reasonable," then nothing but a surgical operation will probably enlighten them. If, on the other hand, the Board is "informed" and does not think the accommodations are "reasonable," why do they not do their duty by "giving notice and information in writing to the corporation," as the law requires them to do, or present "the facts in the case to the Attorney-General, or report them to the Legislature?"

The General Manager of the road is reported in the *Evening Post* of September 9 to have said that no more trains could be run morning and evening with safety than are run now and have been run during the summer. What do the Railroad Commissioners think about this? The General Manager admits that some trains have been laid off during the summer. Is it not a curious fact that it is safe to run more trains at some seasons of the year than at others?

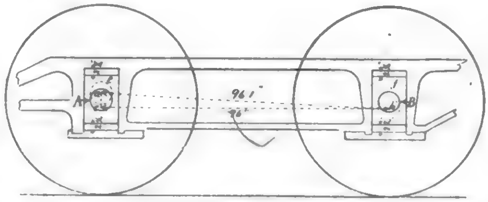
Is it not true that more trains are run on the Third Avenue line than on Sixth Avenue? Why is it safe to run that number on the east side of the city and not on the west side? All these are questions which it is the duty of the Railroad Commissioners to have answered. It is for such duties as these that the Commission has been created. If they do not perform them it might be advisable to abolish the Commission altogether. That would cost less, and the public would then probably be served just as well as it now is, although it is the duty of the Commission to know whether the service of the railroad companies is reasonable.

THE ACTION OF DRIVING-BOXES AND COUPLING-RODS.

It is the general impression among English locomotive superintendents and, to some extent, among American master mechanics, that what are called "single" passenger locomotives—that is, locomotives with only a single pair of driving-wheels—run much more freely and are capable of higher speed than engines with two pairs of coupled wheels. It is not certain that this impression is based on conclusive evidence, and it may be that, like many other general impressions, if it were subjected to rigid investigation, it would be found that to a greater or lesser degree it is erroneous. Experiments to show just how much truth and how much error there is in the impression might throw much needed light on the subject. The purpose of this article is to speculate about it, and in this way to stimulate, if possible, the interest and curiosity of some locomotive superintendents or master mechanics to make an experimental investigation of the subject.

The only cause to which the freer running of single engines has ever been assigned, so far as we know, is to the increased friction due to the effect of the coupling-rods. The pressure on the pistons in a single engine is, of course, transmitted to the crank-pins, and thence to the wheels. In a single engine the pressure on the main crank-pin journal is the same as it would be on a coupled engine, assuming that the size of the cylinders and the pressure in them are alike. In a four-coupled engine, however, one-half of the force exerted on the crank-pin of the main driving-wheels is transmitted to the leading or trailing wheels by the coupling-rods. The pressure of each end of these rods on the crank-pins, to which they are connected, is one-half of that of the main connecting-rods on the crank-pins, so that the coupling of four wheels doubles the crank-pin friction. Besides this, if there is any difference in the diameters of the front and back wheels, it will cause increased friction if they are coupled. If the tires are considerably worn, one pair may occupy a central or normal position on the rails, so that their smallest diameter is in contact, whereas the flanges of the other pair may be crowded on one side toward the rail and on the other side away from it, so that the diameter of each of the wheels at the points in contact with the rail will be greater than it is at the point where the tire is worn most. If the wheels were not coupled, this difference in diameters would have little or no effect; but if they are coupled, one pair must slip during each revolution an amount equal to the difference in the circumferences.

Besides this, an engine with coupled wheels usually has less flexibility of wheel-base than single engines have. Consequently the flange friction, especially on curves, of coupled engines must be greater than it is with single engines. The friction from all these causes must also increase with the number of wheels which are coupled—that is, it is greater on six or eight-coupled engines than it is on those with four wheels connected. The relative increase can probably only be determined by experiment.



But there is another cause, which is perhaps the most potent in increasing the friction of coupled wheels. This is the varying distance between the centers of the driving-wheels. If the practice were not so common, it would seem almost incredible that the most experienced, skillful, and ingenious engineers of the present day would adopt as their standard method of construction one which involved the use of two or more approximately parallel shafts from 6 to 9 in. in diameter, held in bearings connected together with frames of equivalent strength, in such a way that the centers of the shafts may constantly vary in their distance apart, and that these shafts are then connected together with cranks and pins and rods at each end—the cranks at the opposite ends of the shafts being at right angles to each other—and all made enormously strong to correspond with the strength of the bearings, the frames, and the shafts. Notwithstanding the incredibility of this, it is the universal practice in the construction of locomotives with coupled wheels all over the world. The accompanying diagram may, perhaps, make this clearer to some of our readers. The axle A of one pair of wheels is carried in a journal-box e, which can move vertically in the jaws about $4\frac{1}{2}$ in.—that is, $2\frac{1}{4}$ upward and the same distance downward, as indicated by the dimensions above and below the box. The same thing is true of the box f of the axle B. Supposing, now, that the axle A has moved upward the full distance permitted by the space above the box and below the frame, or $2\frac{1}{4}$ in., so that the axle is in the position indicated by the

dotted circle at *a*, and that the axle *B* has moved downward as far as the box *f* and the space below it will permit, or into the position shown by the dotted circle *b*. Evidently the distance from the center *a* to center *b* of the axles will then be greater than the distance *c d*, which indicates that between the centers of the two axles when the boxes are central in the jaws. By the rule that the square of the hypothenuse is equal to the sum of the squares of the other two sides, it will be found that if the axles are spread 8 ft., that the distance apart of their centers indicated by *a b*, when the one has moved upward and the other downward to its extreme limit, is a little more than a tenth of an inch greater than it is when the two boxes are central in the jaws, and the axles are in the position shown by the full circles *A* and *B*. It will be said or thought, doubtless, that the one box is never at the top of the jaw when the other is at the bottom, which suggests the question, How much do driving-boxes move in the jaws while an engine is running? We never knew or heard of any one having made the experiment to determine just how much this movement is. Most master mechanics and locomotive engineers have vague notions, which are deduced from casual observations of the wear of the grease and dirt from the wedges, but we have never been able to find any one who had done even this with care. We seem to be in almost absolute ignorance of the amount of actual movement of driving-boxes when an engine is running. No doubt their movement depends upon the condition of the track, speed, etc., and it might be expected that in running over a frog or crossing or bad joint that the movement would be much greater than it is on a smooth part of a line. It would be a very simple matter to attach an index-rod to one of the back driving-boxes in the cab of an ordinary American engine, and from it observe how much movement the box has. If there were a self-registering apparatus connected with the rod, it would add somewhat to the value of the experiment and greatly to its interest. Having determined how much this movement is, it would be an interesting and probably an instructive experiment to jack up an engine so that its wheels are clear of the rails, and wedge one of the boxes up and the other one down in the extreme positions which it has been found that they assume in actual running. Then kindle a light fire in the fire-box, and open the throttle, and observe how much steam pressure is required to turn the wheels. It may be that it would be very little, and, on the other hand, it seems quite possible that it would be much greater than is ordinarily suspected. We are all agnostics on this subject—that is, we know very little about it. The general impression that single engines run much more freely than coupled engines would seem to indicate that friction is greatly increased by coupling, and it may be that much of it is due to the varying distances between the centers of the driving-axles. If the upward and downward movement is only one-half the amount of play between the boxes and frames, making a total difference in the height of the two boxes of 2½ in., then the difference in the distance between the centers of the axles when the one box is up and the other is down would be nearly one thirty-second of an inch; not much, it is true, and yet a very considerable force would be required to stretch an ordinary coupling-rod that amount.

It may be said that ordinarily there is that much play in the bearings of coupling-rods. This may and may not be the case. When rods are newly and accurately fitted they have not that much play, whereas after running some time they may have more.

But even assuming that they have that much play, in order that the cranks may work freely, it is essential that the maximum and minimum length of the rod may coincide with the least and the greatest distance apart of the axles. If these lengths and distances do not coincide, the rods will bind and cause undue pressure and strain on all the parts. Like the little girl in Dickens's novel, who had to "make believe a great deal" in drinking lemon peel and water instead of wine, so it is necessary to make believe a great deal in thinking that there is a coincidence in the maximum length of the rods and the distances apart of the axles.

There is, in the first place, the inaccuracies in workmanship in boring the wheels for the crank-pins. Quartering machines are not endowed with infallibility, and in slight degrees of mendacity two-foot rules and gravestones emulate each other. Then there is the other fact, that in many kinds of engines the heat of the boiler has a very considerable effect on the frames, and expands them, which increases the distance apart of the axles. Allowance is not always made for this. At any rate, it is often greatly a matter of chance whether the length of the coupling-rods will coincide with the distance apart of the axles when the frames are heated or when they are cold.

Besides these chances of inaccuracy, there is the fact that the wedges, especially when double ones are used, are effective means by which careless or ignorant men may increase or diminish the distance between the axles.

The fact, too, that many more coupling-rods are broken than main connecting-rods indicates strongly that the former are subjected to much more strain than the latter.

It is, of course, impossible now to know, with any certainty, how great the defects in the coupling of engines are; but the considerations which have been brought forward indicate that the whole subject is one of those which has been allowed to drift along without receiving much intelligent attention. If this is the case, it may be that a thorough investigation, and the introduction of methods which would insure greater perfection of working parts and would correct the inaccuracies which are now permitted, and possibly the introduction of new methods of construction, might work a reform of very great importance in locomotive engineering.

It seems in the highest degree probable that coupling-rods often impose tremendous strains on crank-pins, axles, frames, and their connected parts, with a corresponding increase in friction and liability to breakage and accident. The subject seems to be worthy of thorough and intelligent investigation.

TRADE CATALOGUES.

The Brake Pressure Regulator Company, of Chicago, Ill., have issued a circular, 6 × 9½ in., 16 pp., in which their apparatus is illustrated and described. The engravings are outline process cuts, which show the construction and the details of the apparatus very clearly.

The Browne & Sharpe Manufacturing Company, of Providence, R. I., have issued a descriptive pamphlet, 5¾ × 9 in., and about 16 pp., giving information about their exhibit in Chicago. It also contains a considerable amount of collateral information about the business and the establishment of this company.

The Delamater Iron Works, of New York, have sent us two descriptive pamphlets, one referring to the Delamater-Ericsson hot air pumping engine and the Delamater-Rider hot-air pumping engine. To persons interested in this subject, we think these pamphlets contain information of much value, and many whose relations are only with steam-engines will be surprised to find the extent of the various uses to which hot-air engines can and have been applied.

L. Schutte & Company, of Philadelphia, send us a small descriptive pamphlet, 4 × 6½ in., 41 pp., which is intended to describe the appliances which they have on exhibition in Chicago. These include injectors, exhaust steam induction condensers, universal steam jet siphons; eductor or cellar drainer, furnace blower, and various kinds of steam jet appa-

ratus for moving air, gas, and vapors; air compressors and exhausters, hydraulic elevators, and valves and test pumps.

THE RIEHLE BROTHERS TESTING MACHINE COMPANY, of Philadelphia, have sent us their catalogue No. 8. This is a large volume 9¼ × 12 in., containing 56 pp. of engravings and reading matter. The special classes of products described are their standard patent testing machine, molding and countersinking machines, patent ball-bearing screw jacks, pig mill trucks and turn-tables, power, hay, and straw rope twisters, hydraulic pumps and braced railroad and warehouse trucks. The volume is very elaborately illustrated with illustrations of all these various classes of machinery, and of many special details which are furnished. The same firm also send us a reduced copy of the same catalogue, which is somewhat less than half the linear scale of the other, and is thus very convenient for being carried in the pocket.

THE BLOOMSBURG CAR COMPANY, of Bloomsburg, Pa., have issued what they call their catalogue No. 1, which is 6¾ × 9¾ in., and contains 34 pp. This company are manufacturers of freight, mine, dump, ore, and miscellaneous cars, all of which are illustrated in the volume before us. They also illustrate views of car-wheels, lumber trucks, hand cars, and self-oiling wheels. The volume is completed by a wood-cut of Suber's roller bearing, which, it is said, needs no oil, and can be run for months without any perceptible wear. The gain in friction is also said to be at least 30 per cent., and persons interested in this improvement are requested to write for further information. We should rather pin our faith to the cars which this company build than to their roller bearings, which are revived so often and so universally fail.

THE CINCINNATI CORRUGATING COMPANY send us a pamphlet, 4¾ × 9¾ in., 8 pp., on the life of the iron roof, or how long it will last. It gives a considerable amount of interesting information concerning the roofs which this company manufactures. They also send us their illustrated catalogue, which is 6 × 8¾ in , 48 pp. This is illustrated with various diagrams and views showing the method of manufacturing their corrugating sheet metal roofs, of which this company make a specialty. Various details of manufacturing are shown, and much interesting and valuable information is given for those who contemplate using roofing of this or any other kind. It also gives information concerning metal sheathing, corrugating iron shutters, steel roofing, iron weather boring conductors, pipes, etc., all of which is well worthy of the attention of those who need or intend to have a roof over their heads.

THE C. W. HUNT COMPANY, of 45 Broadway, New York, send us several new publications, one their No. 9,306, which is a bound book, 7 × 10 in., and contains 108 pp. It describes at very considerable length the various kinds of coal-handling machinery which are manufactured by this firm, and is illustrated with excellent half tone and wood engravings. It contains so much detail that it would occupy more time and space than we can now devote to it to describe the classes of machinery manufactured by the company. We expect to return to this subject again, however, and, in the mean while, recommend those who need automatic railways, coal elevators, steam shovels, cable railways, hoisting engines, coal tubs, wheelbarrows, coal screens or rope blocks, which are the specialties of the C. W. Hunt Company, to write and get a copy of their catalogue. They have also forwarded to us their list No. 9,305, which has the same size page as the other, and contains 50 pages, and is a brief list of the machinery which the company manufactures. A small pamphlet has also been sent to us which gives some data about their exhibit in Chicago, which will be interesting to those who visit the great show.

THE NILES TOOL WORKS, manufacturers of high-grade machine tools, labor-saving machinery. Hamilton, O.

The new catalogue of this company is 4¼ × 6 in., 96 pp., and is a very convenient size and form. It is illustrated by wood-cuts giving a view of their works, a 48-in. engine lathe, a 60 in. heavy forge lathe, a No. 2 screw machine, a double axle lathe, a wheel press, a car-wheel boring machine, a cylinder-boring machine, three different sizes of boring and turning mills, 60 in. planing machine, a plate planing machine, an 18 in. shaping machine, an 18-in. slotting machine, a horizontal boring and drilling machine, a vertical drill press, a radial drilling machine, and a set of bending rolls. These engravings are printed on a rather yellowish buff tint, which is a questionable improvement to their appearance. Some of the engravings, too, have hardly had full justice done to them in the printing, although most of them are very good examples of the wood-engraver's art.

The descriptive matter is given in English, French, German, and Spanish, and the book is apparently intended for use at the World's Fair, although it is not said so. Its convenience is a great recommendation, and the general execution—engraving, paper, press-work—is excellent.

THE LINK-BELT COMPANIES' engineers, founders, and machinists send us a very neatly printed and illustrated catalogue of the appliances which they manufacture. These include the Ewart detachable link belting, dodge chains, etc.; elevators and conveyers are especially designed for transporting of materials in bulk, or in barrels, bales or in boxes. The first engraving is a very good half-tone cut of the works of the company in Chicago. The next is of their establishment in Nicetown, near Philadelphia, which is followed by another one of their establishment in Indianapolis. There is then given a view of a locomotive coaling station at New Buffalo, Mich., and another in the yards of the Philadelphia & Reading Railroad at Philadelphia. Engravings are also given showing a section of an inclined conveyer for carrying lumber, anthracite coal at a coaling station of the Philadelphia & Reading Railroad. There are also views of a coaling station at Communipaw, N. J., at Wilmington, Del., at Weehawken, N. J. Several views which show an arrangement for conveying barrels are also interesting. There are other illustrations of freight conveyers, horizontal box conveyers, carriers, ice elevators, coal storage plant, a coal rolling pocket, and screen rope drivers and elevator heads, a 225-H. P. main rope power transmission, and interior views of a dynamo-room of the Virginia Hotel in Chicago, and also in the Chamber of Commerce Building—all of which are very interesting and will give the reader an idea of the extent to which this class of machinery is now used.

THE EDWARD P. ALLIS COMPANY, RELIANCE WORKS, Milwaukee, Wis. This company has sent us a new descriptive circular 9 × 12 in., 80 pp. In the introduction it is said, "The following pages are not designed either as a catalogue of machinery or as an elaborate description of our plant, but it is hoped that they will give a fair idea of the magnitude of the establishment and the high character of its productions." A variety of data is then given showing the extent of the works, the amount of manufactured products per year, etc. It is also said that the position of this establishment in its special lines is evidenced by the fact of building the largest stationary steam plant in the world; the largest pumping engine; of first introducing into the United States the triple-expansion and quadruple stationary engines and triple expansion pumping engine; by building the largest flour-mill in the world, and introducing the roller process of flour making in American mills; and building the first practical band saw-mill.

The book is printed on coated paper, and is elaborately illustrated with half tone engravings, the first one showing a view of the works with a portrait of Edward P. Allis, the founder of them. The next shows an interior view of the general offices; another one part of the drawing-room. These are followed by interior views of the foundry, machine shop, the office, the roller mill shop, and the millwright shop. Views are also given of a group of mills and elevators at Superior, Wis., which have been equipped with the machinery made by this company, and also of another mill at Mariner's Harbor, N. Y., several at Minneapolis, Minn., and one at Estill Springs, Tenn., and another in Kansas City. The first portion of the descriptive part relates to the saw-mill work which the company are doing. A partial view of the interior of the saw-mill shop is given, and an engraving of the new Allis band saw-mill, and also a view of the John R. Davis Lumber Company's mill in Wisconsin. These are followed by views of other mills which have been equipped by the Allis Company. The next portion of the catalogue relates to their stationary engine department, and is illustrated by interior views of the erecting shop; of a large Reynolds Corliss engine, and of a similar combined engine and hoisting engine; a vertical blowing engine; a triple-expansion, vertical pumping engine; a Reynolds-Corliss air compressor, and Reynolds rolling mill engine, which completes the book. The views are all excellent, and give a good idea of the scope of the manufactures of this company.

Illustrated Catalogue of Metal Working Machines, Tools, also Steam Hammers, Hydraulic Machinery, etc., manufactured by Bement, Miles & Co., Engineers and Machinists, Philadelphia, U. S. A.

In noticing the catalogue of wood-working machinery issued by J. A. Fay & Co. a few months ago, we thought that the need of superlatives in this branch of literary criticism had reached its limit. The volume before us makes it necessary to refer to our book of synonyms, and hunt up a new lot of adjectives to do it justice.

The size of the book is 12 × 9 in., and contains 358 pages. It is divided into six parts or sections on 1. Lathes; 2 Planing, Shaping, and Slotting Machines; 3. Milling Machines, Upright, Radial, Horizontal and other Drilling Machines, Upright Boring and Turning Machines; 4. Nut Tapping, Plate Bending, Punching, and Shearing Machines; 5. Hydraulic Machinery, including Steam and Hydraulic Riveters; and 6. Steam Hammers for Iron and Steel, and Steam Drop Hammers.

All the illustrations in the book are wood-cuts of the very best kind, made by Markley and J. S. C. Heiss, of Philadelphia, and Chauncey Wright, of New York. All the engravings have a whole page devoted to them. One of them, of a gun lathe, is a double-page inset. The whole of the book is printed on the best quality of coated paper, the press-work and typography being of the very best, and the latter in excellent taste, which is true of everything in the book. There is not the slightest sign of a kind of tropical exuberance which so often mars trade catalogues. Everything, even the descriptions and commendation of the tools and machines made by the firm, is temperate, which gives a tone of veracity to the whole volume.

The first illustrations are external views of the Callowhill and Twenty-fourth Street works of this firm. These are followed by some introductory remarks giving a very brief history of the establishment. After this three very excellent engravings showing the interior of their new shop on Callowhill Street. A good index—often lacking in publications of this kind—is then given, and the opening chapter on Lathes begins. This is illustrated with 25 engravings of different kinds of lathes which have from 21 in. to 125 in. swing.

The second section has 31 illustrations of Planing, Shaping, and Slotting Machines. These vary in size from machines which will plane objects 17 × 17 × 45 in. long to 122 × 122 × any required length. Another machine is described which will plane 146 × 146 in.

In the third section 51 engravings are given of different kinds of Milling, Drilling, and Boring Machines. The largest of these is a boring mill, which will swing an object 25 ft. 6 in. in diameter and 10 ft. 2 in. high, and was illustrated in our April number of this year.

Twenty-six engravings of Tapping, Bending, Punching, and Shearing Machines are given in the fourth section. The part relating to Hydraulic Machinery, Steam and Hydraulic Riveters, contains 15 engravings, which are followed by 15 more illustrations of steam hammers—in all 168 engravings. It can be said of these that there is not a poor one among them, and most of them are of superlative excellence.

As an example of the style of the descriptive matter, the following "General Remarks" on Steam Hammers may be quoted: "In designating or describing a steam hammer, it is rated by the falling weight of the piston, ram, and ram die; thus a 1,000-lb. hammer means one whose piston, ram, and die together weigh 1,000 lbs. This takes no account of the top steam used, which enormously multiplies the force of the blow, nor of the force acquired by gravity in the descent of the falling parts. The rating of a hammer, by the weight of the connected falling parts, is simple and easily understood, while any statement as to the force of the blow is difficult of expression and has no practical value. In general design and arrangement, even to the smallest details, our hammer is as simple as it can be made, and the whole construction is illustrative of a complete adaptation to its purpose. The valve-gear, arranged with the least possible number of moving pieces, takes up its own lost motion by gravity, hence it will control a hammer with great uniformity for a much longer time than would otherwise be possible. Having no connection with the ram, it escapes all concussion. It is so designed as to produce, automatically or by hand, every variation in the length, position, and force of the blow by a single lever with no extra gear. The patented adjustable guides, for taking up the wear of the ram, are an important addition, the value of which has been well demonstrated by the fact that nearly all our hammers are now provided with them. Anvils are usually made with a removable cap of iron or steel, to admit of repair or replacement without the necessity of removing the whole anvil."

GENERAL MARINE NOTES.

Trial Trip of the "Columbia."—In an unofficial trial trip of the *Columbia* made on September 12, she attained a speed of 23.3 knots, thus excelling the performance of the cruiser *New York*. The trial was made off Cape Henlopen. A heavy sea was running and the water was 14 fathoms deep, which were considered very unfavorable conditions. During the run, the total indicated horse power was 15,000 out of a guaranteed 20,000. The maximum revolutions of the engine were 120. Her steering qualities were of the first order. The *Columbia* was then returned to be put in order for her official trip that takes place off Long Island.

Two New English Battleships.—The Navy estimates for 1893 and 1894 provide for two first-class battleships, to be called the *Majestic* and *Magnificent*, which are to be built at Portsmouth and Chatham. Their principal dimensions are as follows: Length, 390 ft.; breadth, extreme, 75 ft.; mean draft, 27½ ft.; displacement, 14,900 tons. With natural draft on the eight-hours contractor's trial a mean speed of 16½ knots is anticipated; with moderate forced draft a *maximum* speed of 17¼ to 17½ knots will be obtained. The armament will include four 12-in. breech-loading guns of new type, mounted in pairs, twelve 6-in. quick-firing guns, sixteen 12-pdr. quick-firing guns, and twelve 3-pdr. There will also be five torpedo discharges for 18-in. torpedoes, four of these being submerged.

Oil-Distributing Sea Anchor.—A cheap and simple device which may prove to be of especial usefulness to fishing vessels in a sea way is an oil-distributing sea anchor, recently invented. It consists of a triangular frame of wood cross-lashed at angles and provided with a span of three legs. Across the interior triangular space of the frame is stretched a piece of canvas, fitted with eyelet holes and laced through these eyelet holes to the frame. To back and support the canvas a piece of netting is laced to the frame. In the middle of the canvas is a patch, to which is stitched a bag consisting of two thicknesses of canvas. The space between these bags is the oil chamber. At the trailing end of the outer bag a simple valve may be placed, or the outer bag may be perforated with sail needles. A towline from the vessel is bent to the span. A simple rubber hose or tube connects with the oil chamber and leads to the vessel, being seized to the towline at intervals so as to insure its being kept slack while the towline is under tension. On board the vessel a pump or bulb syringe is employed to feed the oil into the oil chamber of the distributor as may be desired. For fishing vessels the device may be kept attached to the anchor by a rope of sufficient length to insure that the device shall be awash when in use. The device can then be streamed when the anchor is let go. The anchor may be of any size, and offers a wide field of usefulness.—*Baltimore Journal of Commerce.*

Regularity of the Turning of Steam Vessels.—The loss of the *Victoria* has attracted attention to the behavior of vessels under various evolutions, and Admiral Coulomb has made a statement in regard to the accuracy of the *Edinburgh's* movements. In a test her turning powers were measured so as to fix her position at the moment the helm began to move, and when she had turned an eighth, a quarter, three-eighths, and a half circle. She was turned three times to the right and three times to the left, under the same conditions, at a normal speed of about 12 knots. The result was that, including all errors of observation, chords drawn from the point of starting to the points given above did not vary in length for the eighth of a circle turn more than 22 yds. in 335; for the quarter-circle, more than 25 yds. in 565; for the three-eighths of a circle, more than 25 yds. in 687; and for the half-circle, more than 64 yds. in 716. The angles that the chords formed with the original course of the ship did not vary, for the first chord, more than one degree in 13; for the second chord, more than two degrees in 33; for the third chord, more than two degrees in 58; and for the fourth chord, more than two degrees in 75. As to the times occupied, the accuracy is, perhaps, still more remarkable. The ship turned the eighth of a circle in 66 seconds, with a variation of only three seconds; she turned the quarter of a circle in two minutes and one second, with a variation not exceeding five seconds; she turned the three-eighths of a circle in two minutes and 58 seconds, with a variation not exceeding seven seconds; and she finished the turn of half a circle in three minutes and 54 seconds, with a variation not exceeding eight seconds of time.

Two British Cruisers.—Two British cruisers, to be called the *Powerful* and *Terrible*, have recently been designed, and they are to be the largest cruisers in the world. Their principal dimensions are: Length, 500 ft.; beam, 75 ft.; mean

draft, with keel, 27 ft.; displacement, about 14,000 tons. The continuous sea-steaming speed is to be 20 knots an hour. On an eight hours' natural draft contractor's trial the speed will be about 22 knots an hour.

The hulls of the two ships will be steel, wood sheathed and coppered. It is proposed that the ships shall be able to take the sea and keep it for long periods, and in order that neither shall suffer in speed for want of coal, the designs call for a coal supply of 3,000 tons for each ship. On the 14,000 tons displacement and 27 ft. draft called for in the designs a coal supply of only 1,500 tons a ship is considered. The bunkers, however, will hold 3,000 tons of coal.

The battery of each ship will consist of two 9.2-in. breech-loading rifles mounted, one in the bow and one in the stern, as chasers, twelve 6-in. rapid-fire guns in broadside, eighteen 12-pdr. rapid-fire guns, twelve 3-pdr. rapid-fire guns, and a number of small machine guns. The 6-in. rapid-fire broadside guns will be in such a position as to permit four guns to be fired right ahead and four right astern.

Armor protection will be provided for all the 9.2-in. and 6-in. guns. The 12 pdr. guns on the upper deck will be furnished with strong shields revolving with the guns. The torpedo armament will consist of four submerged torpedo discharge tubes placed in two separate compartments. The engines, boilers, magazines, and other vital portions of the ship will be placed below a strong curved steel deck, having a thickness of 4 in. for a large proportion of the length, with a slight reduction of thickness toward the extremities. This deck will be associated with minutely subdivided coal bunkers extending up to the height of the main deck. This latter feature is identical with that seen in all the late first class cruiser designs for the British Navy.

Battleships for the French Navy.—The plans of the French Admiralty for 1894 include the laying down of three new first-class battleships, each of 12,000 tons. The designs for these new vessels are not yet quite completed, but they are to be protected by a belt of armor the greatest thickness of which will be 45 cm. (17½ in.). Instead of the usual splinter-protective deck below the armored deck, a second armored deck is to be introduced. It is understood that the center batteries will consist of 30-cm. (11.7 in.) guns, and the auxiliary batteries of 16-cm. (6¼ in.) and 10-cm. (3.9 in.) quick-firing guns, and that there will be a very full complement of the lighter guns It is also intended to fix the torpedo-launching apparatus below water. The system of two turrets, each carrying two guns, as practised in England, is to be adopted. The turrets are to be revolving and covered. The guns of medium calibers are not to be placed in turrets in pairs, but singly, behind protective shields, 72 mm. (2.8 in.) thick. The operations of revolving the turrets, serving the guns, and supplying ammunition are to be effected by electricity, the apparatus to be adopted being that used in the *Capitan Prat*, which has proved very effective. It is most likely that the machinery, boilers, etc., will be placed in three separate compartments, and that the new vessels, like the *Dupuy-de-Lôme*, the *Massena*, and the *Bouvret*, will be provided with three screws. With forced draft, a speed of 18 knots is to be attained. If the French Chambers approve of the outlay, concerning which there appears to prevail but little doubt, France will possess, in 1894, nine new battleships in various stages of completion, including the *Brennus* and *Bouvret*, which are being constructed at L'Orient; the *Charles Martel*, at Brest; the *Jauréguiberry*, at La Seynes; the *Lazare-Carnot*, at Toulon; the *Massena*, at Saint Nazaire; and the three new vessels mentioned. Of the ships named, only the *Brennus* has so far been launched; but their completion is to be expected in the following order: *Brennus, Jauréguiberry, Charles Martel, Lazare-Carnot, Bouvet*, and *Massena*. One of the new vessels is to be built at a private yard, the other two being laid down in government dockyards.—*Times.*

New French Cruiser.—A new cruiser, the largest in the French Navy, is ordered to be built at La Seyne, after designs by M. Legane, the constructor of the Spanish battleship *Pelayo*, the Chilian armored cruiser *Capitan Prat*, and other celebrated modern vessels. She will be named the *D'Entrecasteaux*, after the famous navigator who died during his search for La Pérouse, and, as she is intended for service as flagship in distant seas, she will be sheathed and coppered. Her displacement will be 8,114 tons; her length at the water-line, 393 ft. 6 in.; her extreme breadth, 58 ft. 5 in.; and her extreme draft, 29 ft. 6 in. She will have two vertical triple-expansion engines, with five cylindrical boilers, developing in all 14,000 H.P., and giving a speed of 19 knots. The normal bunker capacity is to be 650 tons, but it will be possible to carry 1,000 tons of coal. The protection consists of a 3.9 in. steel deck, with, above it, a great number of cellular compartments for coal and stores, the whole being covered by another steel deck ¾ in. thick. The whole of the hull below the protection is occupied by the machinery, boilers, bunkers, and magazines. Each of the heavier guns has its own separate ammunition hoist. These, and also all the auxiliary machinery, steering-gear, internal lighting, loading and training engines, etc., will be electrical. The armament will consist of two 9.4 in. guns of 40 calibers; twelve 5.5 in. quick-firing, twelve 1.85 in. quick-firing, and four 1.45 in. quick firing, with two submerged and five above water torpedo tubes, two of the latter being in the bows. Each of the 9.4 in. guns will occupy a closed turret covered with 9.8 in. steel. Four of the 5.5 in. quick-firing guns will be on the spar-deck behind 2.8 in. hardened steel shields, and the remaining eight upon the main deck in sponsons behind similar shields. The smaller guns will be distributed over the superstructure and in the tops, of which there will be three—or, rather, a three-decked one—on each of the two military masts. Within the masts there will be the usual staircases and fighting positions, and there will be also a heavily armored conning tower. The *D'Entrecasteaux*, which is estimated to cost $3,017,230, will be somewhat larger than our new first-class cruisers of the *Edgar* and *Crescent* classes, but a little smaller than those of the *Blenheim* type. She will also be exceeded in size by the Russian cruiser *Rurik*, than which, however, she will be a knot faster. In size she will most nearly approximate to the new American cruiser *New York*. Another ship of the class is to be laid down presently.—*Engineering.*

Tail Shaft Preserver.—Mr. T. Mudd, of the Central Marine Engine Works, West Hartlepool, has recently fitted to the propeller shafts of several steamers engined at these works an arrangement for preventing the galvanic action which arises immediately at the ends of the brass liners when immersed in water, and the general corrosive action that proceeds along the middle part of the shaft between the liners when exposed to salt water in the stern tube, and which is aggravated by the churning action produced resulting in the water being largely mixed with atmospheric air. Mr. Mudd holds that the one great essential to be aimed at is keeping the water away from the shaft. This has been attempted in several ways, such as by lengthening out the liners till they meet, and there brazing them together, but he believes it has never been effectually accomplished, and the covering of a shaft with brass all over is a very expensive expedient. Mr. Mudd's patent tail shaft preserver then consists simply of a tube or sleeve, made of first class india-rubber, of such dimensions as to cling tightly to the shaft over the whole length between the liners, and for several inches up the inclined liners at its ends. For this purpose the liners are lengthened out about 6 in. more than is usual, and gradually tapered away to accommodate the elastic sleeve. This gentle tapering of the liners has another good effect, as it gradually diminishes the strength of the liner, and so overcomes the objection to a sudden change of strength where the liner finishes, and which, doubtless, in many cases aggravates the damage caused by galvanic action at that point. When the preserver is to be put on the shaft, the latter is thoroughly cleaned bright, and coated with a suitable cement, and by means of special apparatus of a simple character the sleeve is drawn over the end of the shaft until it is in its place, where it becomes embedded firmly in the cement, clinging so tightly as to make the accession of water beneath it quite impossible. When desired, the ends may be lashed with copper wire over wire gauze, and the lashings soldered together. To prevent any chance of the sleeve being damaged when the shaft is being pushed into its place in the tube, a false nut is provided which runs on the thread on the end of the shaft, the external diameter of which is precisely the same as the diameter of the brass liners, and which therefore holds up the point of the shaft as it passes through, preventing the elastic tube from being injured by the neck bush. This nut, of course, goes with the ship as part of the outfit.—*Journal of American Society of Naval Engineers.*

NOTES AND NEWS.

A High Smoke-stack.—One of the highest, if not the highest smoke stack in the United States has been recently built for the Fall River Iron Company. The stack from the top of the granite foundation to the cap is 350 ft.; the diameter at the base is 30 ft., at the top 21 ft.; the flue is 11 ft. throughout, and the entire structure rests on a solid granite foundation 55 ft. by 30 ft. by 16 ft. deep.

The Trajectory of a Big Gun.—At a test of the coast gun built by Krupp, at the Meppen proving grounds recently, the projectile was fired 65,616 ft. with the gun having an ele-

vation of 44°. The projectile weighed 474 lbs. and a charge of 253 lbs. of powder was used, giving an initial velocity of 2,099 ft. It is estimated that the projectile reached an altitude of 21,456 ft., its flight occupying 70.2 seconds. The Krupps have had a drawing made showing the flight of the projectile relatively to Mont Blanc, in which it is shown that it would be possible for the gun to fire over the mountain from Pre-St.-Didier.

The Gordon Disappearing Carriage.—The Gordon disappearing carriage for the 10-in. breech-loading rifle was tested at the Sandy Hook proving grounds on September 13. The firing was to sea, and little delay was caused by shipping. The record was for 10 rounds, and the last six rounds were fired continuously. Without any deduction of time for delays, the 10 rounds were fired in 59 minutes and 24 seconds. The carriage was worked by hand throughout, the design being independent of power appliances of any kind. The carriage worked remarkably well during the whole test. Full service charges were used, the weight of powder being 250 lbs., and that of the projectile 575 lbs.

Electric Feeder for the Gatling Gun.—A new electric feeder has been applied to the Gatling gun by its inventor at Hartford, Conn. On a strip of tin, 20 smokeless powder cartridges are placed, each held in place by bits of tin turned up for the purpose. These strips are put into a horizontal opening, and as they are drawn through, the cartridges are stripped off and placed in position to be thrust into the chambers. The motion is positive, and there is no failure in any part of the movement. The strips with cartridges attached can be compactly packed, and a much larger amount of ammunition can be carried with the gun than by the old way. The gun can be fed by these strips with the greatest rapidity. With them it has been fired 3,120 times in a minute, and when turned by a little electric motor attached to the breech, it can be fired 5,000 times a minute.—*Electrical Review.*

A New Smokeless Powder.—According to reports from Bucharest a new smokeless powder, known as Plastomenit, has been tested there by the military authorities as well as by the local sporting club. One of the advantages it is said to possess over other similar powders is that its combustion does not choke the gun. Though it proved to be the best of smokeless powders yet tried for the small caliber Mannlicher rifle in use in the Roumanian Army, the results with that weapon were not quite satisfactory. It was, however, found to be everything that could be desired in the matter of carrying power and penetration with the smooth bore guns of the Sporting Club, and is said to be equal, if not superior, to powder of English manufacture. The smoke is hardly perceptible, and the noise of the explosion is very slight, while there is absolutely no recoil.—*London Times.*

Thirteen-in. Gun for the United States Navy.—Considerable attention has been attracted lately to the 13-in. gun which is soon to be tested at the Indian Head proving grounds. It weighs 135,500 lbs.; its total length is 40 ft., and the greatest diameter of the gun body, 49 in. The total length of the bore is 37 ft. 10 in., of which 30 ft. 10 in. are rifled. The rifle consists of 52 grooves, each .415 in. wide and .05 in. deep. The chamber capacity of the bore is 80 in. long, with a diameter of 15 in. The total capacity of the bore is 64,857 cub. in. The shot that it will throw weighs 1,100 lbs, and 550 lbs. of powder will be required for each firing. The muzzle velocity of the projectile will be 2,100 ft. per second. It is also estimated that after traversing a distance of 2,500 yds. the shot will still have a velocity of 1,805 ft. per second. The energy at the muzzle is estimated at 33,627 foot tons. It is expected to have a penetrative power of 24 in. of steel at 1,500 yds. from the muzzle. Brown's prismatic powder will be used in the first test.

Automatic Block Signaling by the Use of Incandescent Lamps.—The Weehawken tunnel of the West Shore Railroad, in New Jersey, which is 4,200 ft. in length, has been fitted with a novel block-signal system, described in the *Engineering Magazine.* The arrangement consists of a line of incandescent electric lamps about 300 ft. apart, and placed on a level with the eye of the engine-driver. When the lamps are all alight it is an indication of safety. Each train passing through extinguishes the lamps for a distance of 1,100 ft. in its rear, a result which is automatically effected by an electrically connected track circuit, whereby the lamps are kept under the continuous control of the train. The operators in the signal towers at each end of the tunnel can also extinguish the lights in any section of the tunnel if occasion requires. This system appears to embody a number of exceedingly valuable features, and, if successful in practice, cannot but increase the traffic capacity of a long tunnel largely beyond that which is possible by the methods of signaling heretofore in use.

Test of Holtzer Projectiles at Sandy Hook.—A test of the 300-lb. Holtzer projectile of American manufacture was made at Sandy Hook on September 5. Two shots were fired, one of which was recovered and the other lost, having gone seaward, although it is hoped that it will be picked up on the shore. The one which was recovered was sent through 9 in. of solid steel backed by 3 ft. of solid oak, and was found 20 ft. back of the oak in solidly packed sand, and was declared by experts to be practically as perfect as when it had been inserted in the breech of the 8-in. rifle. The projectile is made by the Midvale Steel Company, who has purchased the right to manufacture for the whole American Continent from the Holtzer Company of Umieux, France, who control a secret process invented by C. E. Brustlein, for making steel as hard as flint at the same time as tough as copper. When the projectile which was recovered was brought to the surface, it was found that the upset was only .005 of an inch. The initial velocity of each shot was 1,624 ft. per second with the pressure of 23,260 lbs.

Heat of the Sun's Surface.—What is the actual heat of the sun's surface? Various estimates have been made, but as they vary from 1,000 and a fraction to millions of degrees there is little prospect of an immediate and reliable answer to the question. Secchi gave it as his opinion that the temperature could be but little, if any, short of 10,000,000 degrees of the Centigrade thermometer. Sporer thought that it might be 37,000 degrees, while Pouillot brought it down to somewhere between 1,400 and 1,761 degrees of the same scale. M. Becquerrel, Professor Langley and Sir William Thompson all agree on about 3,000 degrees of Centigrade, making their deductions from calculations based on solar photospheres.

According to M. St. Clair Deville, the temperature of the sun's surface does not exceed 2,800°. This also agrees with experiments made by both Bunsen and Debray. Sir Robert Ball, the astronomer royal of Ireland, in his "Story of the Heavens," says: "We shall probably be well within the truth if we state the effective temperature of the sun to be about 18,000° F."—*St. Louis Republic.*

Hydraulic Pump for Mines.—In a new hydraulic pump arrangement just being introduced in some of the English collieries, two columns of water are substituted for the ordinary pumprods connecting the steam-engine with the pump, and which may be placed any distance from each other. Advantage is taken of the fact of water being practically incompressible, and that if a pipe is filled with water a piston at one end will, if pushed forward, propel a piston placed at the other end in the same direction; with two pipes and four pistons a reciprocating motion is obtained. The arrangement consists of a hydraulic cylinder in which works a piston or ram, called the power ram, which is moved by a crank driven by a steam-engine. At the pump there is a cylinder exactly the same as that at the engine, in which is a piston or ram attached to the plunger of a double-acting pump, and a pipe connects the end of the power cylinder at the engine with the end of the motor cylinder at the pump. When both cylinders and pipes are filled with water and the water piston is moved by the engine, the water in the power cylinder is forced through the pipe into the end of the motor cylinder at the pump, and the motor piston is moved. In a like manner, when the power ram at the engine moves that at the pump responds, carrying the pump plunger with it. Thus the pump plunger is moved backward and forward in the same way as if there were a direct connection by means of rods between the steam engine and the pump.—*London Press.*

The Mont Blanc Observatory.—This observatory, which was completed in August, stands 15,781 ft. above the level of the Mediterranean, and is the result of two years' toilsome and dangerous labor by 40 men, who have risked their lives for the benefit of science and mankind. The question arose prior to building as to whether a rock foundation could be had, and in order to determine the fact a tunnel was driven through the ice a distance of 135 ft. on the south side of the peak, 50 ft. below the summit. Finding nothing but sound ice, an incline shaft of 130 ft. was sunk with no better result. An ice foundation was the only choice left, and upon the ice the observatory has been erected. The peak upon which it stands is 126 ft. long and 48 ft. in width. To avoid the disturbing effect of the furious storms which sometimes rage on the summit, the building, as will be seen from the framework shown in the figure, has the form of a truncated cone and is in two stories. The lower story is below the ice crust, about 20 ft., and the upper 18 ft. above the surface. There are six rooms in all, one of which will be reserved for visitors, who will be entertained free of charge during their stay on the summit. The building is supported underneath by jackscrews, so that in the event of its moving from position it can

be screwed back to its place. The rooms are heated by petroleum stoves. The outside temperature in the winter is 40° below zero and about 12° above in the summer. The total cost of this extraordinary undertaking, when completed in August, will reach $60,000. The telescopes and other scientific instruments first used will be of a smaller caliber, as it is necessary to make experiments before buying large and expensive ones.

Submarine Foundations Made by Solidifying Sand.—At the recent World's Congress of Engineering in Chicago, Dr. Neukirch described a method of solidifying sand in the bottom of a river by converting it into a concrete masonry foundation without being excavated or disturbed. The process consists in using air pressure to force dry powdered hydraulic cement through a pipe down into the bed of sand or gravel. The pipe or tube has a lance-shaped foot perforated with small holes through which air is forced. The pipe is sunk deep into the sand and gravel bed by forcing air through these holes, which displaces the particles of sand at its foot and allows it to settle. When the tube has reached a solid substratum the cement is fed into the tube, and the current of air carries it to the foot of the tube, and injects it with considerable pressure into the sand and forms a matrix with the sand, gravel, and water present. The blowing in of the cement and air in this mobile mixture produces a boiling action at the end of the tube which thoroughly mixes the cement and sand. As the process goes on and the introduction of the cement continues, the tube is slowly drawn up at a speed which permits the required quantity of cement to be introduced. As the tube is drawn up and the injection of the air ceases, the grains of sand subside and settle firmly together, occupying a smaller space than before the cement was introduced. Each sinking of the tube gives, of course, only a column of concrete, its size depending upon the pressure of the air and the looseness of the sand. To insure the solidity of the whole foundation, the pit is divided into small fields from 8 to 12 in. square, and into each field the pipe is sunk and the requisite quantity of cement forced. To limit sharply the lateral dimensions of the foundations and to protect it against outside influences, it is in the first instance surrounded with sheath piling or a cofferdam.

The Most Suitable Colors for Signal-posts and Semaphore-arms.—Attention is directed to the difference in opinion which is prevalent with respect to the coloring of railway signals, upon the facility of recognizing which so much depends. There is no desire to question the advantages in favor of the two colors, red and green, which have so long been selected for night signals; it is, however, pointed out, that while the red glasses used for this purpose are, as a rule, admirable, the green glass is frequently of too dark a shade, which renders it impossible to distinguish the light at a distance of more than 330 yds. to 440 yds. In lieu of green glass, it is advisable to substitute the pale, bluish glass, long employed at sea, which transmits a beautiful green light, capable of being seen as such at great distances. This so-called "marine glass" is already in use by some railway companies. In accordance with the new (German) regulations, which came into force on January 1, 1893, red and green disks are to be partly used for day-signaling; and provision is made for keeping them free from dust and dirt, and for repainting them at frequent intervals. It must be determined by time whether enamel colors or "durable" paints prove to be the best for this purpose. All kinds of theories exist as to the best manner of painting the posts and movable portions of the signals, so as to render them readily visible to the engine-driver under all circumstances; and it is time that some definite rules, sanctioned by long experience, were laid down to secure uniformity in this respect. In the investigation of a series of cases where complaints have been made, it has been found that the red color commonly used for the semaphore arms becomes, under certain conditions, extremely difficult to distinguish—namely, when it is seen against a background of foliage. In a given instance the arm was painted white, which gave satisfaction for a time, but as soon as the brilliancy of the new paint had disappeared, and the signal had to be made out in snowy weather on a white background, matters were as bad as ever, so the semaphore was painted red as before, with renewed complaints in the following summer, when the trees became green again. The color, as it deepened with age, was found more and more difficult to make out, and the signal-arm soon had to receive a second coat of paint; it was, however, decided that the red color was more clearly visible than in the year before, when the arm was painted white. Though this represents an individual case, it is a matter of wide experience among railway officials, and arguments are founded upon it against the practice of coloring the arms in alternate stripes of red and white, either horizontal or vertical in direction, as tending to reduce the area of visible color. This does not apply to the posts, which are best painted in bands of black, white, and red, beginning at the bottom with black, in belts about 3 ft. to 4 ft. deep. The following regulations, based upon a practice of many years in duration and extending over a great mileage of railways, are proposed:

1. The semaphore-arms are, as a rule, to be painted bright red throughout their entire surface. In a few rare and exceptional cases all black or alternate cross-bars of white and red may be used, the white stripe to be next the post and red to follow.
2. The color of the arms must be renewed as frequently as may, in special cases, be requisite.
3. The signal-posts themselves are to be painted in alternate bands of black, white, and red, from the base upward.—*Annalen für Gewerbe und Bauwesen.*

A New Method of Casting Steel Ingots.—At the Nykroppa Ironworks, in Sweden, a method of consolidating steel ingots, by subjecting the freshly filled mold to pressure developed by centrifugal action, has been introduced by the manager, Mr. L. Sebenius.

The apparatus consists of an upright shaft in the center of a cylindrical casting pit, carrying a frame of four arms, to each of which is articulated a platform supporting four ingot molds. While the shaft is at rest, the molds are upright, and are filled in the usual way; but when it is set in rapid rotation they fly up into the horizontal position, and a pressure in the direction of the length of the ingot is developed equal to thirty times that due to the column of liquid metal in the mold, which drives the gases out, and produces a perfectly solid casting. Uniformity of composition is also induced, as, on account of the rapid cooling, liquation is prevented. The process, which has now been in use about two years, has been applied to both the Bessemer converter and to the open-hearth furnace. The ingots are free from external defects, and the loss by defective ends has been diminished 40 per cent., the metal being so compact as to bear rolling to finished sizes without the use of the cogging mill. The cost of the apparatus is about £400 for a three-ton and £800 for a ten-ton charge.

No details of the apparatus are given, except in the accompanying figures, from which it appears that the circumference described by the bottom of the molds, when spun up into the horizontal position, is about 67 ft., corresponding to the working speed adopted of 125 revolutions to a velocity of nearly 10,000 ft. per minute. The pressure on the mold, taken at thirty times the depth of the ingots, will be about 150 ft. of iron, or from 500 lbs. to 600 lbs per sq. in. In the form of the apparatus intended for smaller ingots the molds are arranged in an inclined position, and radially to a central fixed vertical feeding tube upon a turntable, which is set in rotation after filling, or the latter operation may be performed while the table is actually in motion.

The second notice contains figures of a modification of the apparatus, in which the rotating table, being smaller in diameter than that previously adopted, can be driven at a higher speed, up to 200 revolutions per minute. There are eight pivoted molds, each divided by internal walls, so as to give nine small ingots, suitable for wire billets or thin sheets. By means of a central annular funnel, lined with refractory material, and provided with eight feeding spouts, or one for each group of molds, the whole number of 72 ingots are cast by a single pouring from the ladle, which contains from four to six tons of steel.—*Proc. Inst. of C. E.*

A Persian Telegraph Line.—The mode in which telegraph lines in Persia under native control are erected and worked is described by the British Consul at Resht in reference to the line between Enzelli, on the Caspian, and Resht, and Teheran. In dry weather, he says, the line works fairly well, but in damp or rainy weather it cannot be counted upon. The reason is that the insulators are driven into trees that have branches growing round the hooks and touching the wires, thus intercepting the current if the tree is a large one; but when a large tree is not available a small one is used, and this often breaks, or the shaking of the slender tree by the wind dislodges the insulator or hook on which it is fixed, and the wire trails on the ground. The Consul has often seen the wire right across the high road, which is followed by hundreds of mules both in Ghilan and Astrabad, not only interrupting telegraphic communication, but endangering the lives of the animals and their riders, more especially when the accident happens on the brink of a precipice. It is not surprising, under these conditions, that telegrams in Persia are not received punctually. In one case a high foreign official telegraphed to Teheran from Europe announcing his intended arrival at Resht

in a fortnight. The telegram was received at Teheran the same day by the European line and immediately dispatched to Resht by the Persian line. The fortnight elapsed and the high official arrived. The telegram was received in the sender's presence 18 days after its dispatch. With regard to telegraphic communication through the Persian lines, as all messages are received on the instrument by "ear" and no "tape" record is kept, mistakes almost always occur when the message is in cipher, also when figures, such as sums of money, are mentioned or foreign words or names are transmitted.—*London Times.*

Singular Drainage Arrangements.—A peculiar combination of circumstances has resulted in a remarkable drainage system being employed in a coal mine near Sykesville, Pa. The company owning the coal land also operated a railroad running near the place where the seam of coal cropped out, which made it desirable to begin mining at that point. The seam of coal sloped down from this outcrop to a place about two miles distant in a straight line, where it began to rise again. The surface of the ground over this low point was 116 ft. above the bottom of the seam of coal, and considerably lower than the elevation of the point where the seam came to the surface. It was decided to sink a vertical shaft to the lowest point of the coal, and then tunnel from the foot of this shaft up through the inclined bed to meet a tunnel driven from the point of outcrop. The vertical shaft was 12 × 16 ft. in cross section, and was provided with two pumps capable of removing about 1,250,000 galls. in 24 hours. After nearly three years of work the tunnel down through the coal seam was completed. It is 9,100 ft. long and about 9 ft. wide, the height depending on the thickness of the coal. When it was completed it was found that a horizontal plane through the top of the vertical shaft would cut the tunnel about 4,600 ft. from the outcrop, and so it was decided to discontinue the use of the pumps in the shaft and allow the lower half of the tunnel to fill with water, which would be prevented from rising more than 4,600 ft. from the end by the free overflow it would have at the top of the shaft. The shaft is now full and overflowing, and in this way 2,500 acres of coal land are being drained without any expense for pumping. As soon as all the coal is mined out above this water level, which will probably be many years hence, the water can be pumped out and the remainder of the territory mined.

A Safe for Express Messengers.—An invention to balk train robbers has been devised by E. B. Pope, Western Agent of the Chesapeake & Ohio Railway at St. Lous, and he has applied for a patent upon it. The scheme provides for equipping every express car safe with two locks, which interlock with each other. Lock No. 1 can be either an ordinary key lock or a combination lock. In either case the messenger can handle his money packages for the way stations the same as under the present system. Lock No. 1 is connected with lock No. 2 by a small steel bar, which works in and out of the combination lock No. 2 as the messenger locks and unlocks lock No. 1; the tumblers in lock No. 2, when in their normal position, being always set at "open" and held in that position by a simple mechanism to prevent the jar of the train or an accidental knock from throwing them out of position and locking lock No. 2. A metal cover hinged to the safe fits closely over the dial plate of lock No. 2, and is fastened with a small padlock when the safe is not in use to prevent maliciously disposed persons from causing trouble by throwing off the combination of lock No. 2. When he starts on his trip the messenger unlocks the dial cover and swings it back out of the way, leaving him free to throw off the combination of lock No. 2 when the alarm is given. The messenger knows the combination of lock No. 1 or has a key to unlock it, but he does not know the combination of lock No. 2, and if he once throws off the latter it is impossible for him to unlock and open the safe. A notice is painted on the outside of the safe, instructing the messenger to throw the combination of the lock No. 2 in case of assault by robbers. The inventor says that any two combination locks, or one key lock and a combination lock, can be connected together at small expense so that they will work in unison, and the present stock of safes and messengers' chests now in use can be cheaply equipped with the new device, although it would probably be found desirable to make a quality of messengers' chest that would be too heavy to carry off and strong enough to successfully resist anything but a long and persistent attack by professional safe blowers. —*Railway Age.*

Agricultural Implements in Sicily.—Agriculture is yet in its most primitive state throughout the island. No new inventions, no labor-saving machines, have found a place in Sicily, nor is any appliance known that was not in use generations—in fact, ages—ago. Wheat and oats are harvested, principally by women and children, with the sickle, and the grain is tramped out by horses and donkeys. There is not a reaping, mowing, or threshing machine in this entire district. The plow used by the farmer to-day, incredible as it may seem, is the wooden stick, the round iron point, the long beam extending from the point and resting on a yoke across the necks of donkeys. In Sicily, however, the plow divides honors with the hoe, as only about one-half of the agricultural area is plowed, the other being broken by hand with the hoe. This hoe, with blade 10 in. to 12 in. long by 5 in. wide, and heavy handle about 2 ft. long set at an angle to the blade of about 45°, is the universal work tool of the Sicilian. With it the farmer's land is broken and crops cultivated. Irrigation and ditching, as well as street and road construction, are done with this crude implement. That there is dire necessity for better farm implements and for such tools as the shovel, spade, fork, and wheelbarrow is most evident; but that their introduction here is probable, or that these people could be induced to discard the old and take up new tools, is extremely doubtful.

There is believed to be an opening here, however, for American manufactures of various kinds, such as threads and certain cotton textiles, lamps, small stores, hardware, office furniture, and stationery, provided color, weight, size, etc., together with the peculiarities of the trade and business customs, are considered and catered to. Three-fourths of the manufactured articles bought in this market are supplied by Germans, for the reason that both American and English manufactures are too heavy and expensive. The German learns this by coming here and ascertaining what is most salable and then manufacturing his wares to meet the requirements of the market. Yet in many instances he represents his article to be of American manufacture, or that it is made after American designs. That such representations aid him in his sales fully demonstrates the fact that the people here recognize the superiority of American manufactures, and it is believed that this would facilitate their introduction; but to avail ourselves of this market, its peculiarities and conditions must be known, and this can only be accomplished by sending capable representatives here. The statement should be emphasized that price-lists and circulars sent to addresses obtained from consuls are never productive of good results.—*U. S. Consular Reports.*

When Coal was First Used.—Though coal had been employed for centuries in the manufacture of salt on the shores of the coal fields, wood had hitherto continued to be the fuel at the inland salt works. The use of coal at Nantwich is mentioned as a novelty in 1656; at Droitwich wood fuel and leaden pans were in use up till 1691. In this era the sea salt manufacture was in the zenith of its prosperity. But the substitution of coal for wood in the inland salt trade, aided by the discovery of rock salt, which took place accidentally in boring for coal in Cheshire, led to the gradual decline and final extinction of the manufacture of salt on the coast. The only traces now remaining of this once flourishing industry exist in such names as Howdon Pans on the Tyne, Prestonpans on the Forth, Saltcoats in Ayrshire and Saltpans in Arran and Kintyre, or in the Scottish proverb, "Carry salt to Dysart," synonymous with the English "Carry coals to Newcastle."

In no branch of industry was the scarcity of wood more keenly felt than in the smelting of metalliferous ores. Continued efforts to accomplish this with coal began immediately after the accession of James I., and were persevered in throughout the seventeenth century. But for a prolonged period the new fuel proved highly intractable, and scheme after scheme ended in failure and disappointment.

After eighty years of oft-repeated trials the tantalizing problem remained unsolved. Wood and charcoal still held the field in the smelting furnaces, and all hope of ever seeing coal substituted for them had well-nigh died out. In 1683 Sir John Pettus, in his "Essays on Words Metallick," concludes his observations regarding sea coal and pit coal with the remark, "These are not useful to metals."

The unpromising prospect, however, soon began to brighten. Immediately after the revival of lead and copper mining, which took place about 1692—having probably been more or less in abeyance through the interruptions occasioned by the civil wars—these ores came to be smelted with coal. The extraction of silver from lead with coal was accomplished by a Mr. Lydal in 1697, and the same individual appears to have been the first to successfully employ coal in the smelting of tin, in 1705.

The ores of iron proved more refractory, no substantial and permanent success in smelting them with coal being obtained till near the middle of the eighteenth century, when the manufacture of charcoal iron had dwindled to very small proportions—in fact, was dying out for want of fuel.

It then at length became an accomplished fact at Coalbrookdale Ironworks in Shropshire. The success was at first ascribed to the Shropshire coal, but probably the employment of a strong blast had a great deal to do with it. From this the coal became the life of the iron manufacture. The *ci-devant* drooping trade rapidly revived, and the latter part of the eighteenth century saw coal iron furnaces in successful operation throughout the kingdom. —*Contemporary Review.*

AMERICAN AND ENGLISH LOCOMOTIVES.

(*Continued from page* 420.)

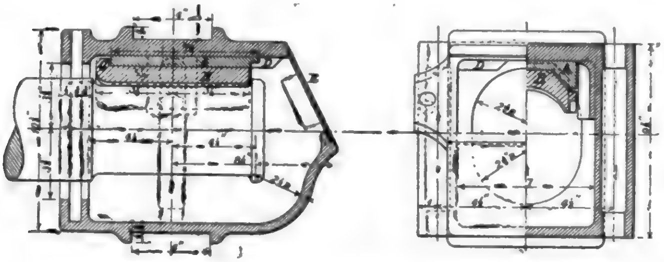
THE parts of the locomotives which are illustrated this month are the tender frames and running-gear, of which the following are the specifications for the American engine:

TENDER FRAME.

Substantially built of 6¼ × 4¾ in. angle iron and thoroughly braced. The back end to be fitted with "Gould" coupler.

TENDER TRUCKS.

Two four-wheeled side bearing trucks made with wrought-iron side-bars and wood bolsters.



TENDER OIL-BOX FOR AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

SPRINGS.

Made of best cast steel, tempered in oil.

WHEELS.

Krupp's steel-tired plate wheels, 36 in. diameter. Tires held by retaining rings.

AXLES.

Of hammered iron, with outside journals 4¼ in. diameter and 8 in. long. Brakes on front truck only.

The specifications for the corresponding parts of the English engine are as follows:

SIX-WHEELED TENDER.

Principal Dimensions.

	Ft.	In.
Diameter of wheels on tread	3	9¾
Center to center of journals	6	6
Length of journal	0	9
Diameter " "	0	5¼
Diameter of axle in wheel	0	6¾
" " " at center	0	6¼
Wheel-base	13	0
Length of frame	19	9¼
Total length of wheel-base, from center of leading bogie wheels of engine to center of hind wheels of tender	44	3¼
Length over all, from front buffers of engine to hind buffers of tender	53	8¾
Height of center of buffers from rails	3	5

TENDER FRAME.

The frame-plates, cross-stays, stretcher-plates, hind buffer-plates to be of steel, same quality and manufacture in every respect as specified for the engine main frames.

Each frame is to be made of one plate, ⅞ in. thick, and all holes are to be marked and drilled from one template. The axle-box guides are to be made of cast iron, planed, fitted, bolted to frame, and must be free from cross-winding and square with the frames in all directions. The horn-stays are each to consist of two 1¼ in. bolts with cast-iron distance pieces accurately fitted between the horns. All the cross-stays are to be accurately fitted to the frames and riveted to them by ¾-in. diameter rivets. The frames are to be accurately tested by longitudinal, transverse and diagonal measurement, and must be perfectly parallel to each other. The front buffing and draw-beam is to be constructed as shown, and is to be provided with buffers fitted with volute springs to this company's pattern. The draw-bar is to be forged in one, the hole at one end being punched. Wrought-iron steps are to be provided, roughed and fixed where shown. The hind buffing and draw-plate is to have a draw-hook and bar furnished with one of Spencer's No. 6 india-rubber cylinder to this company's pattern, two cast-iron buffers the same as specified for the engine, two side chains and screw coupling made of best chain cable iron, and to drawing. Two steel life-guards are to be bolted to the frame, behind the hind wheels.

AXLE-BOXES.

The axle-boxes are to be made of cast iron fitted with a wrought-iron top, and with the best gun metal bearings lined with Dewrance's anti-friction metal, and to have cast-iron keeps provided with lubricating pads. The axle-box bearings to be $\frac{1}{16}$ in. shorter than the axle-journal to give clearance; front and hind axle-boxes must have ⅛ in. side play, and the center axle-box ¼ in. side play on each side of the guides, as shown in drawing.

SPRINGS.

Tender springs to be same quality, workmanship and manufacture as specified for the engine springs. Each spring to consist of 16 plates, one plate ½ in. thick and 15 plates $\frac{7}{16}$ in. thick to a span of 4 ft., each spring to be provided with hangers at the ends and buckles in the center, as shown. Each spring to be tested with a weight of 8 tons, and must resume its original form after testing.

WHEEL-CENTERS.

The wheel-centers to be of good sound cast steel of approved make, quality, and manufacture, and tests same as specified for engine. Each wheel-center to be turned to a diameter of 3 ft. 3¾ in.; the rims are to be 4⅞ in. broad, 2⅝ in. thick at center, to have 10 spokes 2⅛ in. thick at the boss and 4 in. deep; at the rims 1⅜ in. thick and 3½ in. deep. The bosses are to be bored out parallel to a diameter of 6⅞ in., and are to be 11¾ in. diameter. All the centers must be bored and turned strictly to template, so that they shall be exactly alike, and each wheel-center must be forced on the axle by a hydraulic pressure of not less than 70 tons. The wheel centers are to be fixed to the axles without keys.

TIRES.

The tires to be 3 ft. 9¾ in. diameter on tread, and in every other respect to be same as the engine tires, both as regards section, quality of material, and workmanship, and to be manufactured by Vickers & Company. The same tests to be applied as for the engine tires.

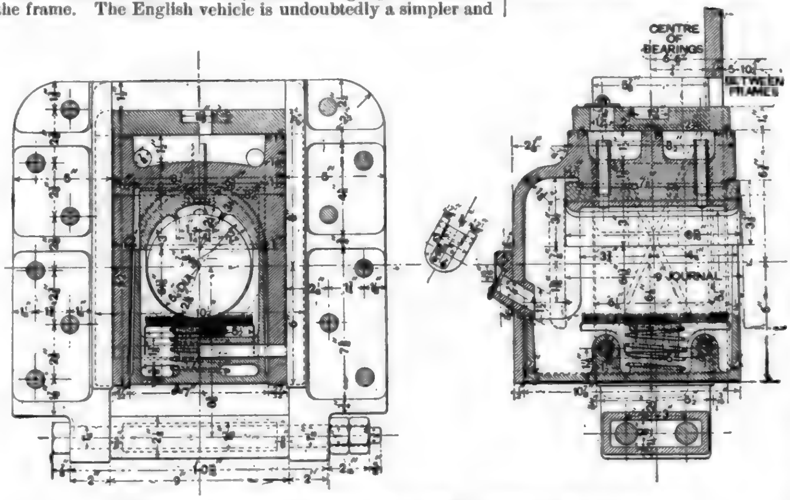
AXLES.

Each axle must be made of the very best cast steel, quality and tests as specified for the engine axles, and to be manufactured by Vickers & Company. Centers of journals to be 6 ft. 6 in., diameter, 5¼ in., and length, 9 in.; other dimensions as shown in drawings.

STEAM-BRAKE.

A steam and hand-brake combined is to be fixed on tender, as shown; the cylinder, 10 in. diameter, is to be provided with means of lubrication; the brake-screw, which is to be left-handed, is to work in a cast-iron column bolted to the foot-plate at the front end of the tender, and the front pulling rod is to be provided with adjustment as shown. Each wheel is to have one cast iron brake-block applied to it. The brake-gear is to be made of the very best hammered scrap iron, all the pins and working parts being of wrought iron case-hardened, all pins to be to drawing and to have brass bushes when shown. The steam is to be led from the engine to the cylinder with a connection, as shown.

The brake material, which must be obtained from the Vacuum Brake Company, 32 Queen Victoria Street, E. C., for each tender, will consist of one main air-pipe with the necessary T-pieces, elbows and clips, one of Clayton's hose and couplings for the front of tender, one of Clayton's hose and couplings for back of tender, one end pipe with cast-iron bend, one dummy, one dirt recipient. The brake cylinder, piston and rod complete are to be supplied by the contractor. The brake-gear generally to be as shown in drawing.



TENDER OIL-BOX FOR ENGLISH EXPRESS PASSENGER LOCOMOTIVE.

In the construction of these tenders it will be seen that there is quite a radical difference, which is characteristic of the practice here and in Europe, the American tender being supported on two four-wheeled trucks, while the English vehicle is carried on six wheels, which are rigidly connected to the frame. The English vehicle is undoubtedly a simpler and cheaper structure than the American tender. To the objection that the weight must be carried on six wheels and journals instead of eight, as in the American tender, it may be said that the English wheels are 45¾ in. diameter and the journals 5½ × 9 in. long, while the American wheels are only 36 in. and the journals 4¼ × 8 in. The carrying capacity of the six English wheels and journals is therefore probably quite as great as that of the eight under the American tender. There are fewer of them, and consequently their first cost and expense of maintenance must be less, and besides there are no truck frames, which add materially to the complication and cost of the American vehicle.

It will, no doubt, be said that the rigid wheel-base, which is 13 ft. long, of the English tender will not adapt itself to short curves as well as the flexible American trucks. To this it may be said that the relation of wheel-base to curvature is one of degree only. With the ordinary curves in use no one now objects to the six-wheeled trucks, with 10 ft. of rigid wheel-base which are used under heavy cars. Wheel-bases of over 13 ft. are in constant use under 10-wheeled, mogul and consolidation engines, and are not a source of any trouble. For the rigid wheel-base it may also be said that it is safer in case a tender gets off the track than two trucks would be. Almost anything is safe while on the track; the danger begins when it gets off.

It is, therefore, believed that very much can be said in favor of the European frame of six-wheeled tender in preference to ours with two trucks and eight wheels. When vehicles of greater length than a tender are used, then the double-truck system has very great advantages over a rigid wheel-base. This is the case with long locomotives and cars, and in this direction European practice is conforming more and more to ours. With reference to tenders, however, the same reasons do not apply, and it is believed that in this country we have entertained an unreasonable prejudice against a practice and form of construction which is simpler and cheaper than ours, and less costly to maintain and not so liable to get out of order.

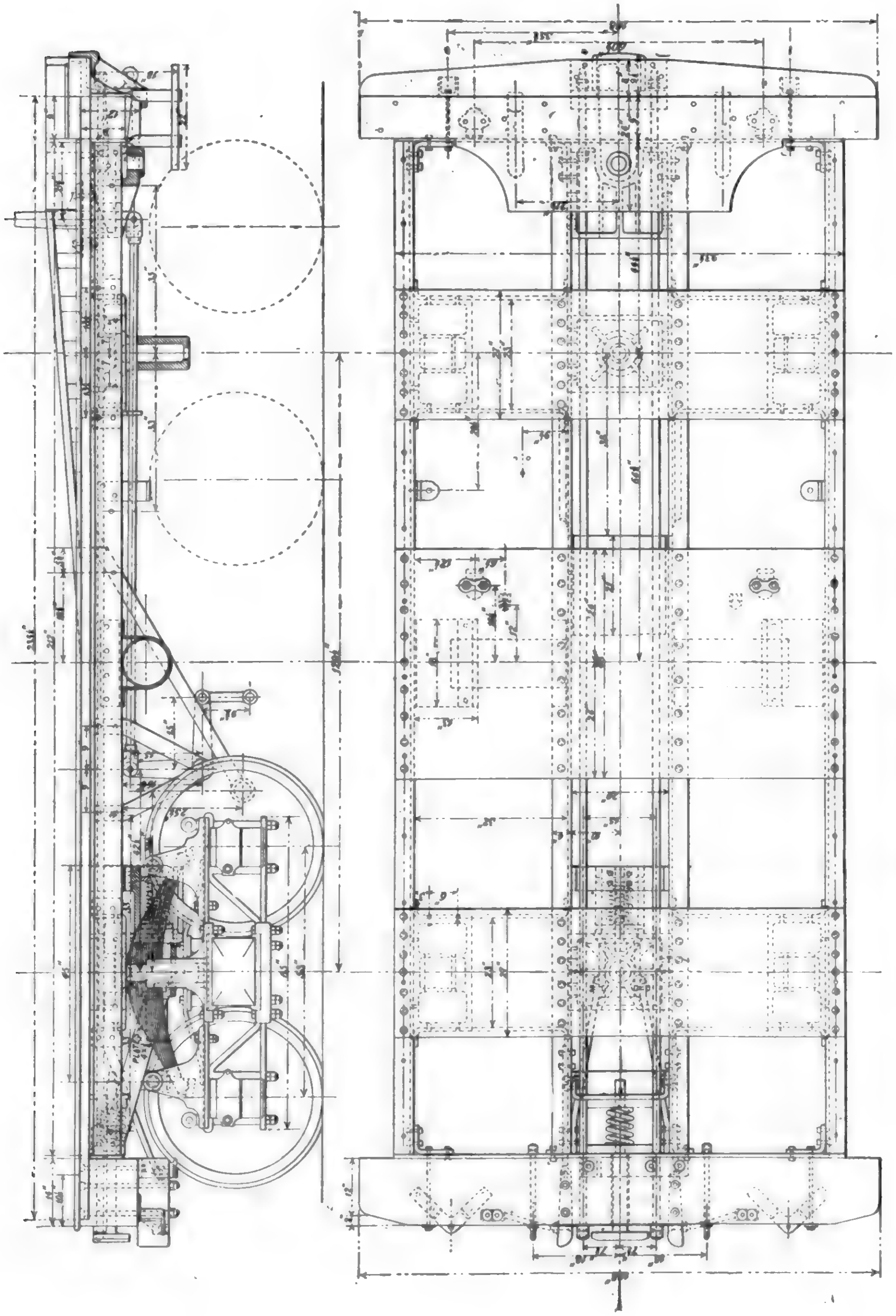
When we come to the tender frame, however, the English practice does not commend itself so highly. The modern shapes of angle and channel-bars, etc., or the Fox pressed steel would seem to afford means of constructing a tender frame for a rigid wheel-base, which would in many ways be preferable to the plate frames which Mr. Adams, in company with nearly all other locomotive superintendents in England, are using. It is said that the experience on the Pennsylvania Railroad with the six-wheeled tender, which was sent over with the Webb compound locomotive, has been in every way satisfactory. It is certainly good policy, when we find that any other practice than our own is better than what we have been doing, to adopt it, and it is believed that if American locomotive superintendents would adopt the European form of running-gear for tenders, it would be an advantage to the companies by whom they are employed.

In one respect, however, the English practice in tender construction seems to be inferior to ours. We refer to the axle-boxes. By referring to the engravings of these parts it will be seen that the journal-bearing *B* bears against a key *A* on top of it. This key is held in its place in the box by lugs *D*, and in turn the flange *C* holds the bearing *B* in place. The box has a cover or lid *E*, which gives access to the journal-bearing and key, and also to the packing which is supplied below the axle to lubricate it. In order to remove or insert a journal-bearing, all that need be done is to raise up the tender so that the key *A* will clear the lugs *D*, and it can then be drawn out through the opening, which is closed by the lid *E*. When it has been taken out the bearing *B* may be raised up so as to clear the collar on the axle, and can then also be removed and a new one put in its place. This can all be done in less time than it has taken to write the description of the process, by merely putting a screw or hydraulic "jack," similar to one illustrated on another page, below the box, and raising it up about half an inch. All the packing in the box used for lubrication may be removed without raising up the box and by merely opening the cover *E*. It will also be noticed that the whole box is made in one piece, so that there can be no leakage from it, excepting around the axle or where the dust-guard is placed.

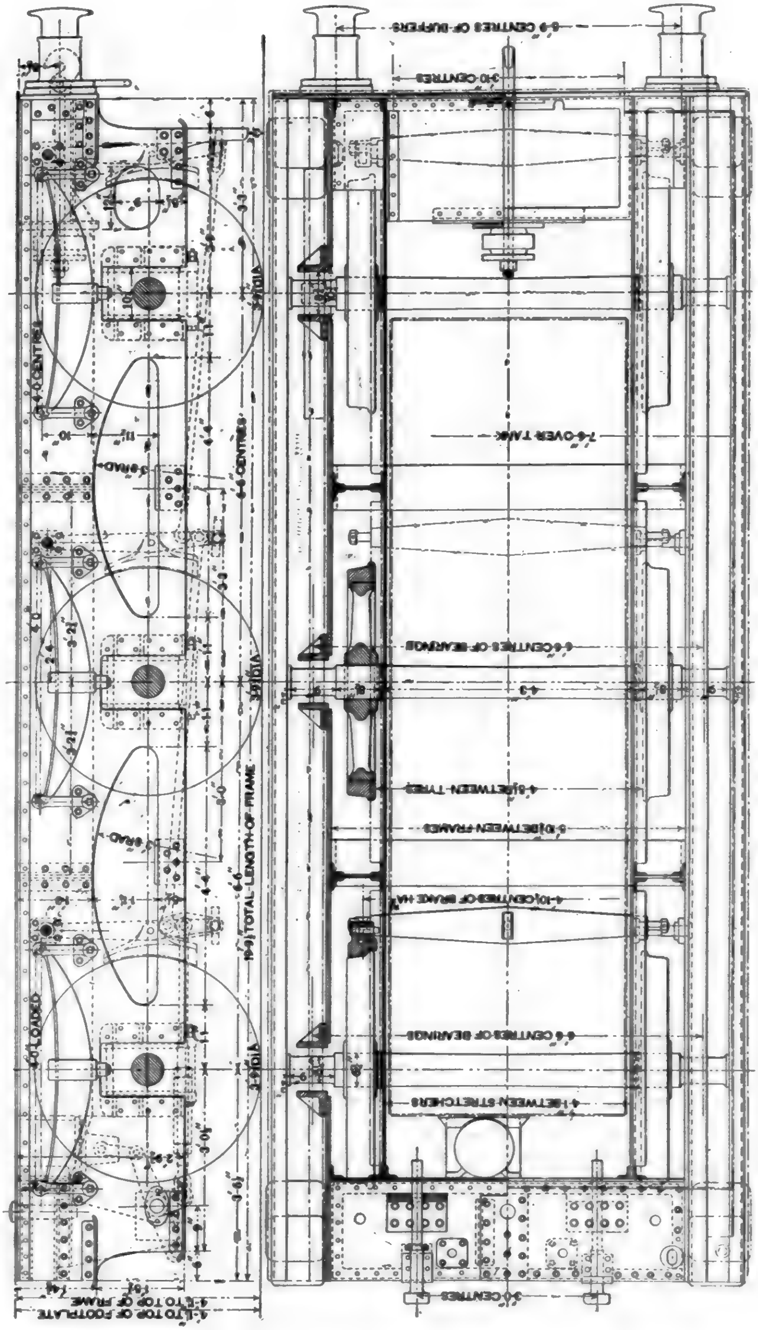
The English box and the oil-cellar are made in two parts, and these it would seem must be liable to leak and allow the oil to escape. Besides, the journal-bearing cannot be removed without taking the axle out of the box To do this the oil-cellar must be taken out, which cannot be done without raising the tender, so that the jaws or "horn-plates" are clear of the box. In other words, the box must be taken out of the jaws and the axle removed from the box to get out a journal-bearing.

That the American box is much the most convenient and must save a great deal of time in renewing bearings seems obvious. As every one knows, the renewal of a worn-out bearing and replacing it with a new one and repacking the box is the work of only a few minutes, and is done daily and hourly on all our roads.

Of the other details of the tender nothing more need be said. The drawings will well repay study to any one interested in the practice in the two countries.



TENDER FOR AMERICAN EXPRESS PASSENGER LOCOMOTIVE.



TENDER FOR ENGLISH EXPRESS PASSENGER LOCOMOTIVE

BLOWING ENGINES.*

By Julian Kennedy, Pittsburgh, Pa.

The different types of blowing engines in use are so numerous that it would not be practicable to consider them all in this paper. I shall therefore only take up briefly a few well-known types.

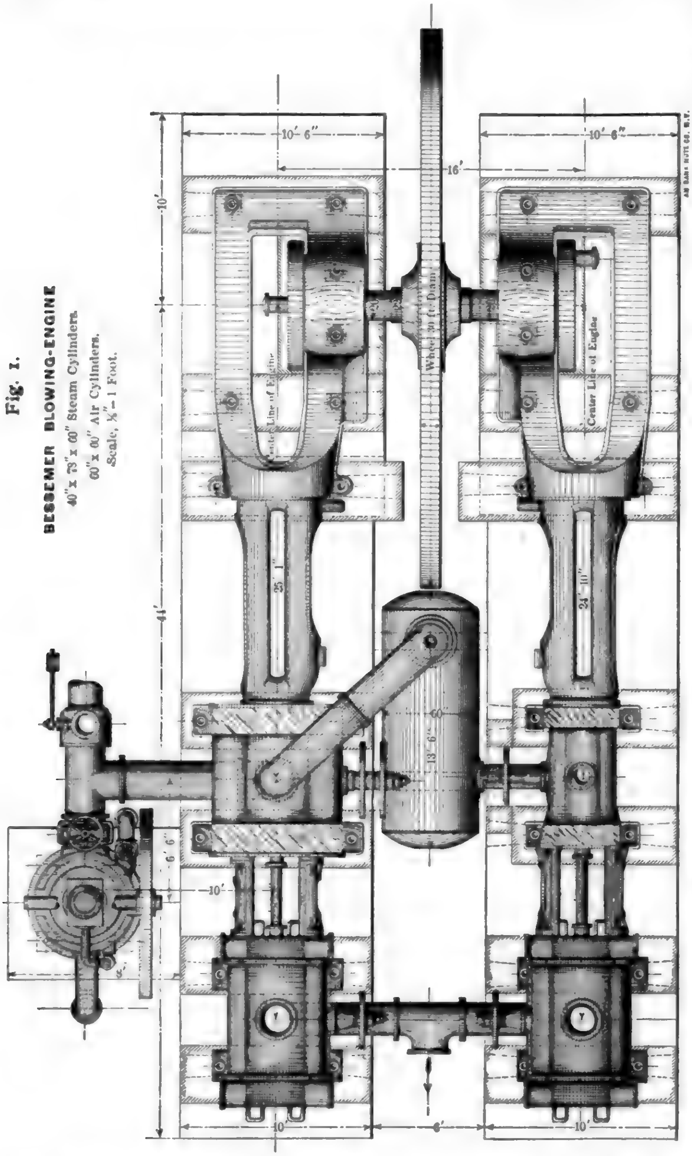


Fig. 1.

BESSEMER BLOWING-ENGINE

40"x 73"x 60" Steam Cylinders.

60"x 60" Air Cylinders.

Scale, ⅛"=1 Foot.

The style of blowing engine most largely used in this country is the vertical engine with air cylinder above, cross-head between steam and air cylinders, and two fly-wheels, each having a wrist-pin in its hub or in one arm. This kind of engine can be built cheaply, takes up little room, and is very accessible. Its disadvantages are that the cross-head is liable to break, and that putting the wrist-pins in the wheels tends to set up vibrations in them. It is likely that on the whole this type of engine will continue to be built quite extensively.

The same general arrangement has also been used to some extent, but not widely, in horizontal engines. The Bethlehem Iron Company has some very fine blowing engines of this type, except that they are compound, having the one steam-cylinder replaced by two side by side. These engines are noticeable not only for the very excellent workmanship on them, but also on account of the weight of the pistons being carried by steam pressure applied to these chambers through the hollow piston-rods. This arrangement, I believe, has always worked well.

Another type of engine which has given good satisfaction is the vertical double engine, having air-cylinders above, steam-cylinders below them, and cranks at bottom, the engines being coupled to cranks on the ends of the shaft, placed at right angles to each other, the shaft carrying the fly-wheel at its center. Engines of this type, except that they are arranged horizontally, are also used to a considerable extent. These engines avoid the disadvantage of having wrist-pins in the fly-wheels, and also dispense with the long cross-head, with its attendant disadvantages. They give a very uniform pressure of blast, and are very convenient for starting. The vertical engines of this type, as compared with the horizontal, take up less room, and the wear on cylinders, due to carrying the weight of pistons, is avoided. On the other hand, the machine is very high and there is considerable vibration. The horizontal machine avoids this, is very accessible, and is cheaper to construct. With proper attention there seems to be no serious trouble with wearing of cylinders, so that wherever ground room is ample the horizontal double-coupled engine seems to be very suitable. The principal objection urged against this style of engine is that in the event of a break a large machine is disabled, whereas, if two single engines are used, one can keep the works going while the other is being repaired. This is doubtless correct; but I think that too much weight is often given to this consideration. With machines strongly proportioned and carefully built there should be very few stops; on the other hand, in the case of Bessemer engines, which are starting and stopping at short intervals, the fact that one attendant can handle the double machine is worthy of consideration.

The double-coupled type of engine is also particularly adapted to compounding. As most blowing engines run under a comparatively constant load, and as the increasing use of water-tube boilers in iron and steel works renders it easy to maintain high steam pressures, I have no doubt that before long compound blowing engines will be adopted in a large majority of the new plants built.

In looking over the different kinds of blowing engines, we cannot fail to be impressed with the fact that in nearly every case the air valves are the weak point in the machine. In the great majority of cases the maximum speed of the engine is about half what it could be if the air valves could work fast enough. To remedy this fault several plans have been resorted to. In some cases fairly good results have been obtained by making the valves very light, giving them but little lift and arranging them so that they shall seat by gravity. In some cases valves of this kind are so constructed that the air, in entering the cylinder, is compelled to pass through a large number of very small openings. This is a very objectionable arrangement, not only on account of the increased amount of friction, but because the air, in passing over the metal grids in thin streams, will absorb quite a considerable amount of

* Paper read at Chicago meeting of the American Institute of Mining Engineers.

heat from the heads, which, in the case of engines working against high blast pressures, are made very hot by the heat of compression.

This heating of the incoming air expands it and proportionally reduces the weight of air entering the cylinder at each stroke. I have observed this in the case of an engine which was so constructed as to cause the air to travel about 3 in. over the hot metal in thin films about $\frac{3}{16}$ in. thick. Alongside of it was another engine of the same size and make, except that valves were used which allowed the air to pass over about 1 in. of metal, the openings being of such size that each stream of air was 2 in. in thickness. Careful and repeated tests of these engines, when both were in good order, showed that while the indicator diagrams were practically the same, the one with the large valves would burn about 10 per cent. more coke in the furnace—a result which could only be explained on the supposition that, in the case of the engine with small air openings, the incoming air, in passing through the small and tortuous passages in the heads, was heated about 25° C. more than in the case of the other engine. It is plain, therefore, that a blowing engine should have air valves which will not only give ample area of inlet passage, but give this in a small number of good-sized openings.

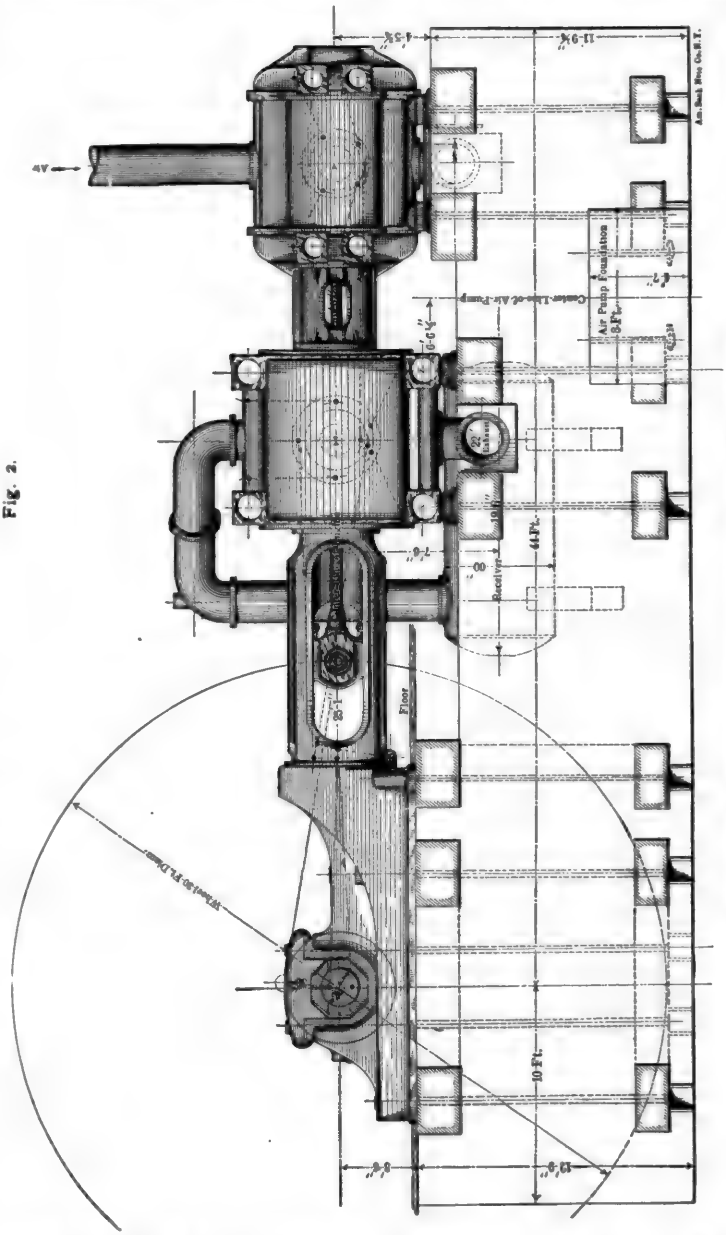


Fig. 2.

ELEVATION OF BESSEMER BLOWING-ENGINE SHOWN IN PLAN IN FIG. 1.

Figs. 1 and 2 are the plan and elevation, and fig. 3 is the diagram of air valves and valve gear of a compound horizontal blowing engine now being constructed by the well-known builders, the E. P. Allis Company, for the Ohio Steel Company. The engine is a Reynolds-Corliss cross-compound; steam cylinders, 40 in. × 78 in.; air cylinders, 60 in.; stroke, 60 in., with re-heater in intermediate receiver, and is provided with an independent condenser. In general design this engine, as will be seen at a glance, is very similar to the large quadruple-expansion engine by the same builders to be seen at the Exposition. The air cylinders are so arranged as to draw the air through pipes which project above the roof of the building and to discharge it below the cylinders.

The inlet valve is a plain rotary valve held to its seat by the blast pressure, which is admitted to the back of the valve by a port from the discharge chamber, and is driven from a wrist-plate. The outlet valve, as will be noticed, is a tripleported valve, which is closed at the proper time by the wristplate.

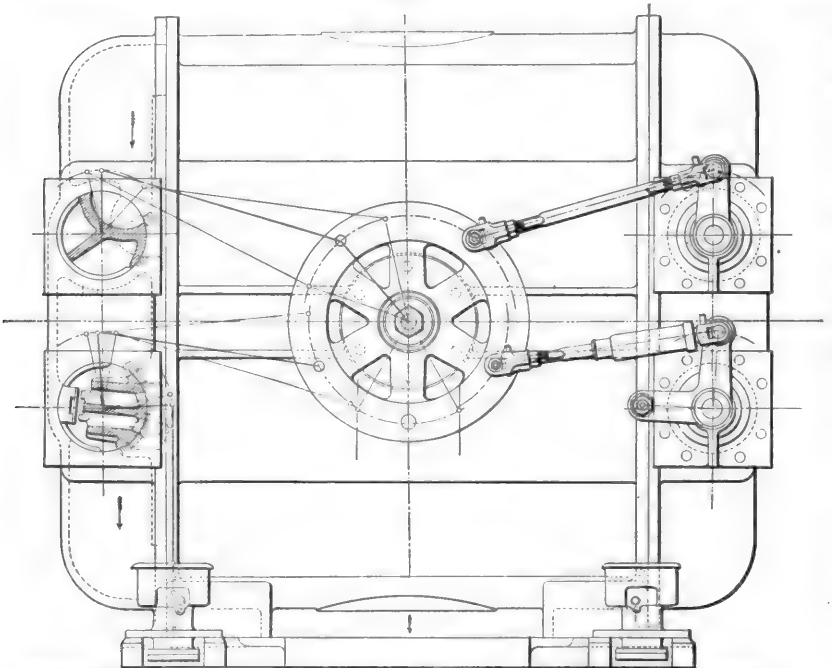
The connection between wrist-plate and valve is made by a telescopic extensible rod, which pushes the valve shut, but permits the wrist-plate to reverse its motion without pulling the valve open. To the valve lever is attached a vacuum pot which tends to pull the valve open. When the valve has been closed it is gripped by the receiver pressure acting on the back, holding it against the seat, and remains stationary during the return stroke of the piston and also while the piston advances toward it again, until it has compressed the air in the cylinder to nearly the same pressure as in the receiver, at which time the pressure on the back of the valve becomes so nearly balanced that the vacuum pot can move the valve, which is then quickly thrown open. The telescopic connecting-rod is so constructed that a small dash-pot is formed at the bottom of the tube to avoid shock should the plunger strike the bottom while the valve is opening or when the closing motion begins. It will be observed that no trip or releasing gear of any kind is used with these valves, the holding and releasing being done by friction, controlled in the simplest possible manner by the air pressure in receiver and cylinder. The outlet valves are also held against their seats by long flat springs bearing in the center on the back of the valve and at ends on blocks set in pockets at end of the valve. It will be

seen from the drawings that these blocks have a clearance of ½ in. at the bottom, so that if for any cause the valve should be prevented from opening at the proper time it will be only forced back from the seat, the opening of ½ in. being sufficient to allow the engine to run at full speed with wrist-plate and vacuum-pot disconnected from outlet valves. This valve gear is extremely simple, and practical tests have shown it to work admirably. This engine is intended to run at a speed of 60 turns per minute if necessary.

In conclusion, the tendency in designing blowing engines seems to be in the following directions:

1. Compounding.
2. Obtaining valve gear which will give liberal openings at both inlet and outlet, and which can be operated at a fairly rapid speed.

Fig. 3.



ELEVATION OF AIR-CYLINDER AND VALVE-GEAR 40 AND 78 X 60 AND 60 X 60 BESSEMER BLOWING ENGINE FOR THE OHIO STEEL CO., YOUNGSTOWN, O. Scale ½ in. = 1 ft.

The latter advantage can probably be best secured by the use of metal valves operated as far as possible positively, which will also do away with the vexation due to the use of leather, gum, and other short-lived materials.

THE MULTITUBULAR BOILER.

In commenting on an article which has recently been published in an American paper, in which the credit of the invention of the tubular boiler is claimed for Marc Seguin, a Frenchman, a correspondent of the *English Mechanic*, asks, "Can any of your readers say where the true facts are recorded?"

This correspondent then says further:

"It should be borne in mind that there are two distinct ideas involved: 1. The invention of the tubular boiler. 2. Its adaptation to the locomotive engine. Regarding the first, it seems preposterous to ascribe it to Seguin, because Smiles, in his 'Lives of the Engineers,' states that as early as 1780 (before Seguin was born), Matthew Boulton employed in the boiler of the Wheal Busy engine in Cornwall longitudinal copper tubes through which the fire passed, and on August 27, 1784, James Watt, in a letter addressed to Boulton on the subject of a locomotive he was planning, says: 'Perhaps some means may be hit upon to make the boiler cylindrical, with a number of tubes passing through.' It follows that even if Marc Seguin had constructed a locomotive with tubular boiler before the date of the *Rocket* in 1829, he would only have adapted to the locomotive that which had long been in use in stationary boilers. But I can find no evidence that he did construct such a locomotive, while there is strong presumptive evidence that he did not. *He took out a patent* for a tubular boiler in 1828; but James Neville, of Shad Thames, London, did the same thing two years earlier (No. 5344, March 14, 1826), and it is at least as likely that Seguin took his idea from Neville (who expressly mentions that his tubes may be used either vertically or horizontally) as that George Stephenson took his from Seguin. Perdonnet, in his 'Traité Elémentaire des Chemins de Fer,' says (Volume II., p. 360):

"'In 1825 and 1826 Marc Seguin, in association with the son of the illustrious Montgolfier, together with his brothers, made the first attempts at steam navigation upon the Rhone. This is the first occasion upon which a tubular boiler was used, but another occasion soon presented itself where this boiler was to be used with still greater advantage. In 1825 the Seguin Brothers obtained a concession to build a railroad from St. Etienne to Lyons, and in 1827 used a tubular boiler on a locomotive. In February, 1828, he took out a patent for this boiler.'

"On the strength of these statements, evidently communicated to Perdonnet, that writer dubs Seguin 'Inventeur de la Locomotive a Grande Vitesse,' and even (Volume II., p. 361) 'Inventeur de la Locomotive.' A careful examination of the wording of this extract will, however, disclose such ambiguity as to make it at least doubtful that Seguin ever practically applied his so-called invention. The words (literally translated), 'it was then that for the first time he made use of a tubular boiler,' do not necessarily imply that he invented the boiler, but only that he applied it. Further, the expression 'en 1825 et 1826' leaves it in doubt as to which year the actual trials were made. Now, Neville's patent was taken out early in 1826, and he mentions the marine boiler as the type to which his invention is particularly applicable. In the same year Seguin visited England to see George Stephenson's engines. Further, Seguin's patent only bears date 1828. It is scarcely likely that he would have made public trials of an invention he intended to patent before protecting himself. Now comes another circumstance apparently inconsistent with Seguin's claim to have even contemplated the application of the tubular boiler to locomotives before 1829. Smiles, in his 'Lives of the Engineers,' says that in that year George Stephenson supplied two locomotives to Seguin for the Lyons & St. Etienne Railway *fitted with water tubes*. These were a failure, and were afterward replaced with fire tubes. Is it conceivable that Seguin would have ordered such locomotives if he had previously had experience of those with fire tubes, which were a success from the first? But there is another still more puzzling fact. In the article 'St. Etienne,' *Encyclopædia Britannica*, it says the Lyons & St. Etienne Railway was opened *in* 1831.

"I leave out of consideration altogether the clearly-established fact that George Stephenson avowedly borrowed his idea of the tubes from Henry Booth, who said he had never heard of Neville's patent, much less Seguin's."

THE STEERING OF BALLOONS.*

By Rudolphe Soreau.

III.—EXPERIMENTS AT CHALAIS-MEUDON.

Balloon Ascensions of La France.—Between the two ascensions of the Messrs. Tissandier there were the well-known experiments of Renard and Krebs. On August 9, 1884, according to the report of Herve-Mangon, the balloon *La France*, having on board its two inventors, started from the military post of Chalais-Meudon in calm weather, and made evolutions with the greatest ease and then returned to Chalais, where it descended upon the same lawn from which it started. In spite of the groves, fig. 10, with which it was surrounded, it traversed about 4⅓ miles in 20 minutes. "As soon as we had reached the top of the wooded plateaus which surround the valleys of Chalais," says Commandant Renard, "we started the screw, and had the satisfaction of seeing the balloon immediately obey it, and readily follow every turn of the rudder. We felt that we were absolutely masters of our own movements, and that we could traverse the atmosphere in any direction as easily as a steam launch could make its evolutions on a calm lake. After having accomplished our purpose we turned our head toward the point of departure, and we soon saw it approaching us. The walls of the park of Chalais were passed anew, and our landing appeared at our feet about 1,000 ft. below the car. The screw was then slowed down and a pull at the safety-valve started the descent, during which, by means of the propeller and rudder, the balloon was maintained directly over the point where our assistants awaited us. Everything occurred according to our plan, and the car was soon resting quietly upon the lawn from which we had started."

This experiment was widely commented upon and provoked a great enthusiasm. It was, nevertheless, merely a trial ascension, in which the aeronauts had not dared to employ the whole of their motive power, and had hastened back to the starting-point, desirous as they were of giving themselves a practical demonstration, which they had prepared for later. The later ascensions were made with a longer run and under atmospheric conditions which were less favorable.

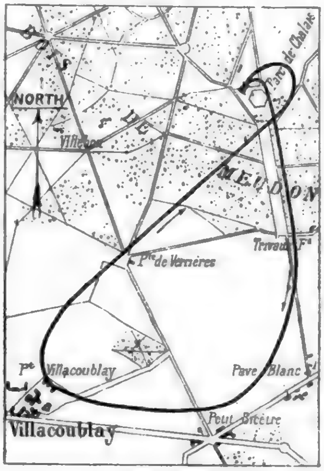


Fig. 10.

The second took place on September 12, in a wind of 20 ft. velocity, against which the balloon struggled without being blown back. It moved against the current, with the whole battery in action, but the engine turned with such great rapidity and heated to such a degree as to oblige them to stop the current. At the time when Commandant Renard was manipulating the commutator the ring broke, and the balloon, deprived of its machine, was carried to Velizy, where a landing was made without any other accident. This want of success, due to an accident to the machine, which was without importance, caused the brilliant demonstration of August 9 to be forgotten, and turned public opinion against it in a most unreasonable way. It was therefore necessary to do away with this bad impression, and a new ring was made by Gramme. On November 8, 1884, the balloon ascended with Messrs. Renard and Krebs, and rose in fine weather and turned toward the Bois de Bologne, fig. 11. It went until Billancourt lay directly beneath it, and was then taken back to Chalais with the greatest of ease. Under the action of the entire battery they attained an average speed of 20 ft. 8 in. per second. The route is represented by a full line. In the afternoon the aeronauts made a new start, and contented themselves, on account of the gale which was blowing, with evolutions around the park without losing sight of it. The route is represented by a broken line. The destruction of a portion of the winding wire did not prevent the balloon from reaching the starting-point, but the average speed dropped to 13 ft. 1.5 in.

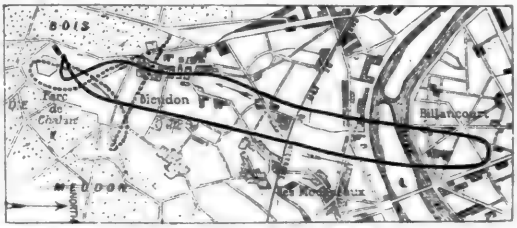


Fig. 11.

To avoid other mishaps Commandant Renard obtained the assistance of Gramme, who constructed a motor having the same weight as the old one, but stronger and a little more powerful; this last circumstance, and the lightening of certain parts permitted them to take a third aeronaut with them and to obtain measurements of their speed. These experiments were made in August of 1885. I content myself here in adding that they were made by Messrs. Charles and Paul Renard, accompanied by Dute-Poitevin, a civil aeronaut attached to the Military Establishment of Chalais. The last ascension, that of September 23, 1885, was made in the presence of the Minister of War, and was a long run, fig. 12. The balloon started against the wind and went to Paris, where it described an elegant curve, the irregularities of which proved in a striking manner the power of the motor, and the certainty with which the balloon could be manipulated. After having crossed the fortifications it returned with the wind behind it to Chalais, which it reached in less than one-quarter of an hour. In this ascension the average speed was greater, or 21 ft. per second.

The following table gives a summary of the seven ascensions of the balloon *La France*. We see that it came back five times out of seven to the point of departure.

Dates.	Number of turns of the Screw per Min.	Average Speed of the Balloon.	Remarks.
August 9, 1884.	42	15.75 ft.	Balloon came back to Chalais.
September 12, 1884	50	18.7 "	Accident to the machine, descended at Velizy.
November 8, 1884.	55	20.67 "	Balloon came back to Chalais.
November 8, 1884.	35	13.23 "	Balloon came back to Chalais.
August 25, 1885.	65	20.67 "	Wind with a speed of about 22.96 ft.; descent was made at Villacoublay.
September 22, 1885.	55	20.67 "	Balloon came back to Chalais.
September 23, 1885.	57	21.33 "	Balloon came back to Chalais.

Since that time Commandant Renard has made no other ascensions. It was sufficient for him to demonstrate to carefully investigating men that the steering of balloons is not Eutopian, and can be accomplished in a utilitarian way. After these few months of glory Chalais went back into a calm, and, as we have said, it wishes to remain so, the experiments announced for the next spring having been made without any particular publicity. While appreciating the motives for this discretion, I regret for my own part that it has been so complete, and I declare here that it should permit all the explanations which can be given to an enlightened public that do not actually constitute a truly interesting secret of national defense.

* *Mémoires de la Société des Ingénieurs Civils.*

We see now how Messrs. Renard and Krebs have obtained such results. "We have been guided in our work," they say in a note to the Academy of science, "by the study and work of Mr. Dupuy de Lome, in regard to the construction of his balloon in the years of 1870 and 1872, and furthermore, we have undertaken to fulfil the following conditions in addition to what he has done; stability of route was obtained by the form of the balloon and the arrangement of the rudder. Diminution of resistance to progress by the choice of dimensions; the centers of traction and resistance were brought together in order to diminish the movement which tends to disturb the vertical stability. Finally, the speed was obtained which was capable of resisting the winds which prevail for about three-quarters of the time in our country" I shall show as rapidly as possible the means which were employed to realize these conditions.

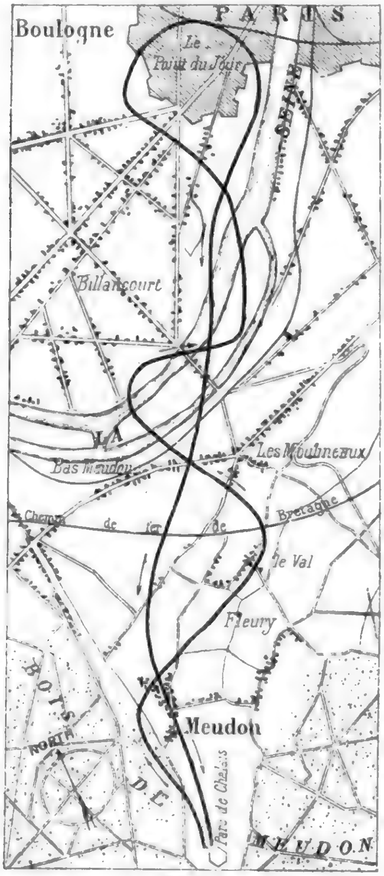


Fig. 13.

Lightness of Motor.—The motor of 1884 was a Gramme machine which Commandant Krebs knew combined a lightness hitherto unknown; it had a power of about 8½ H.P., and only weighed 220.5 lbs. The motor which it replaced, and which was designed with the assistance of Gramme, gave 9 H.P. with the same weight.

The electric generator was a battery designed as a result of the researches of Commandant Renard. The hydraulic reservoir containing five times as much liquid as in the batteries of bi-chromate was attached to the battery, and provided with a switch which permitted them to obtain either a strong current of short duration or a weak current of long duration. Experience has shown that it was advantageous to place these switches so that about 1½ volts below the maximum are obtainable. The great total energy of the Renard battery is due principally to the substitution of chromic acid for the bi-chromate, whose alkaline base absorbs, in the reaction, a portion of the exciting liquid. Its capacity reaches its maximum when the weight of the chromic acid is equal to five-sixths that of the hydrogen acids. Then 55 watts per square decimeter of zinc per hour is obtained. The rate of current is obtained by the partial or total substitution of hydrochloric acid for sulphuric acid in the bi chromate batteries; the total energy of the mixture does not change, but the energy per second increases with the proportion of hydrochloric acid, and can be quintupled. Finally, Commandant Renard has made a most careful study of the influence of geometrical forms and the relations of the position of the two electrodes

Generally it is superfluous to insist upon the merit of an apparatus which has been discovered, that increases by one-half the capacity and quintuples the power of the best batteries which have been known up to the present time. It is to the Renard battery that science owes the magnificent experiments which I have presented to you, and it may readily be said of this battery that it is the soul of the new dirigible balloon. I have shown in fig. 13 a group of 12 elements connected at the top in sixes; this group weighs 22.05 lbs., and it needs four of them to deliver 1 H.P to the shaft. A non-amalgamated zinc pencil of very small diameter is surrounded by a positive polar piece formed by a cylinder of platinum-plated silver of .004 in. thick. The whole is plunged into a glass jar, where chromic acid dissolved in the exciting liquid is found.

The motor drives a two-armed screw 23 ft. in diameter on a hollow shaft, the length of which is about 49 ft. It is held in oscillating bearings, which in turn are held in place by tightening screws This shaft while running assumes a curious bending motion, but not such as to produce any abnormal resistance.

Resistance to Advancement.—Messrs. Renard and Krebs studied very carefully the means of diminishing the means of resistance to advancement. The elongation of their balloon, the length of which was 165 ft. 4.3 in., with a volume of 65,000 cub. ft., fig. 14, was almost equal to the elongation of the second balloon of Giffard, but was made so that it did not compromise the safety of the aeronauts.

The main junction was placed about one-quarter of its length back from the front end. The meridian was composed of two parabolic arcs having for their axis of intersection the main junction with the meridian plane. This unsymmetrical form adopted for the keel of ships is equally applicable and desirable for that of dirigible balloons; furthermore, nature has also given this same form to birds, as well as to fishes. To determine the approximate ratio of the prow to the poop, the officers at Chalais constructed solids of ebonite of the same length, but in which the main junction had a different position. They let them fall into the water with the same velocity, and chose as a model for the dirigible balloon the one which in its descent moved without any sway. It is evident that this means of research was a very rough one.

As in the Dupuy de Lome balloon, an air balloon of calculated dimensions permitted them to be certain of an invariability of form, and a housing replaced the netting. Up to that time they had made housing of the same material as that of the balloon, which compelled them to strengthen it by bands placed transversely, so that it could work in this direction. Commandant Renard used transverse bands, and thus obtained a very marked reduction of weight.

The suspension by a triangular system suggested by Dupuy de Lome was not sufficient with the elongation chosen. Finally, in order to avoid overturning, the officers of Chalais designed another arrangement, the details of which they have not made known, but the efficacy of which has been proven by experience. Instead of passing through the same nodal point, the balancing ropes were grouped in two systems; they were attached to two transverse pieces which started from these bands and were attached about the center of the car. The length of the latter was limited to 108 ft. 3 in., the suspension cords, which held it almost vertically to the bolster, were light and short; they were drawn almost exactly in two planes parallel to the axis. This arrangement singularly diminished the resistance due to the cordage, which was only equal to about one-half of the total resistance with the system laid down by Dupuy de Lome; furthermore, the center of traction and the center of resistance were brought nearer together, and consequently the disturbing moment of traction was diminished; but it diminished the stability of the system at the same time, since its center of gravity approached that of the mass of air displaced.

The car, formed of four bamboos fastened together by twisted wire stays, was covered with silk, which was drawn perfectly tight, giving a far less resistance than would have been the case had basket sides been used. It had a height of 6 ft. 7.8 in. at its center, and was not accessible throughout its

whole length. The aeronauts were at the height of windows made in the sides.

Certainty of Route.—The unsymmetrical form of the balloon by separating the center of inertia from the back evidently increased the efficacy of the rudder. The latter was made of two pieces of silk stretched very tight upon the same frame, but very slightly separated one from the other, so as to constitute two quadrangular pyramids of a very slight height joined to one another. The inventors have not given any reason why they adopted this form; for my part I think it an excellent thing, in that it seems to have had the effect of rendering the resistance of the air upon the rudder practically

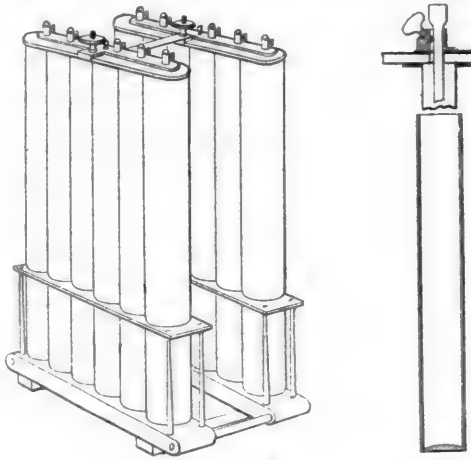


Fig. 13.

perpendicular to the frame, while with the ordinary form this resistance produced, especially at high speeds, a greater or less concavity, which was accentuated on that side which was farthest removed from the balloon, and which had the effect of laying down upon the axis of the dirigible the resultant of the pressure of the air upon the rudder.

On its own part the unsymmetrical form of the balloon contributed very essentially to guarantee stability of route. Let fig. 15, $X X'$, be the route followed, $A V$ the direction of the wind, $A Y$ that of a relative wind, which is the center line of the car, $A B$ the figurative length of the speed proper. In constructing the parallelogram of speeds, we find how it results for the wind with a speed $A C$. Suppose that suddenly this speed changes and becomes $A C_1$. For a very short instant which follows this variation, by virtue of the speed acquired, the balloon continues to follow the route X. On the other hand, the proper speed preserves the same magnitude, since the screw continues to make the same number of turns; if, then, we trace from the starting point, C_1, a straight line $C_1 M_1$ equal to $C M$, we obtain the new direction of the relative wind. Struck by this relative wind $A B_1$, which is no longer directed along the axis of the balloon, the balloon itself turns around the vertical of the center of inertia, so as to place itself in the direction of the wind as it was in $A B$. In what direction, then, will this rotation take place? The prow presents itself to the current while the poop drops away from it.

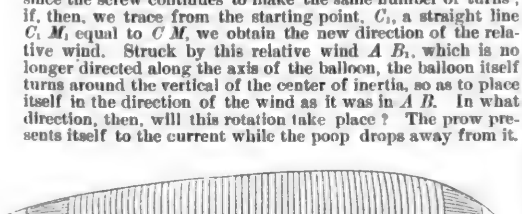


Fig. 14.

It is therefore clear that in symmetrical balloons, fig. 16, the push will tend to make it execute a turn about which increases in rapidity as the arm of the lever $I H$ increases. On the other hand, we can combine the dimensions of an unsymmetrical balloon, fig. 17, so that the poop, in spite of its dropping away, receives the greater part of the effort of the wind; it is necessary, therefore, that it should have a sufficient length. The pressure, then, presents itself as indicated by the figure. A turn-about, therefore, is not to be feared, and a few oscillations set the balloon quietly in its new axis in line with the relative wind.

Finally, the location of the screw at the front end facilitates the action of the dirigible against the wind; and, as has been said, this position was very judiciously chosen. If we should attempt to roll over rough ground a wheel-barrow with a flexible frame, there is no doubt but what we could pull it easier than we could push it. Is it not the same case with the balloon? The structure is of flexible material, the cordage and basket can only be moved through the air at the expense of great effort. Furthermore, the screw placed at the front end has an advantage of moving in air which has not yet been disturbed by the passage of the balloon.

So that it is not only the elongated form of the car which contributes, by being drawn out in a direction of least resistance, to increase the stability.

Progress Made and Improvements to be Developed.—From this slightly protracted analysis the result was that the officers of Chalais-Meudon had very fortunately fulfilled the delicate conditions imposed by the nature of the problem. With the exceptions that the vertical stability had not been obtained automatically, though if I have a good memory Commandant Renard had formerly examined into this matter.

Formerly, when vertical oscillations of two or three degrees were encountered, they were set down to the account of the irregularities of the form or the local currents of air in a vertical direction. I have attributed this, for my part, to the too slight distances between the balloon and the car from which there results a diminution of the couples of stability, which becomes powerless to overcome the imperceptible oscillations of the abundant movements produced by variations in the wind, vertical instability, or any other cause.

The comparison of the resistance measured in the ascensions of 1885 with those which had previously been made by Dupuy de Lome, and which were verified in their totality by the experiments of 1872, have convinced me that the many precautions taken at Chalais, to diminish the resistance to advancement, have not given all the results which could be expected. I will return further on to these conditions.

To measure the progress accomplished by Messrs. Renard and Krebs, it will be sufficient to glance at the following table, where I have brought together the principal characteristics of the balloons which we had examined:

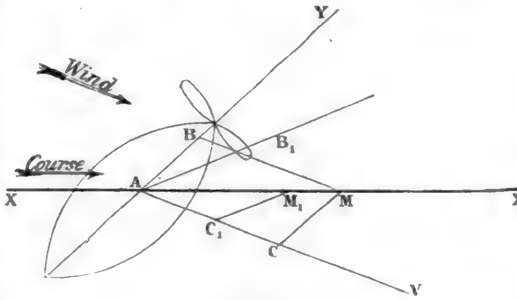


Fig. 15.

	Volume.	Elongation.	Main Union.	Horse Power on Shaft	Mo. Power per 100 sq. yds. of Principal Connection.
	Cu. ft.		Sq. yds.		
Giffard, 1852........	88,290	3.6	145.8	3 H. P.	3.18 H. P.
" 1855........	103,010	7	93.87	3 "	4.58 "
Dupuy de Lome....	127,140	2.43	172	.65 "	.46 "
Tissandier, 1884....	25,320	3.04	79 53	1.5 "	2.7 "
Renard & Krebs....	65,880	6	66.26	9 "	19.5 "

This progress will assume the same prominent characteristic when we couple it with the routes followed by *La France*, figs. 10, 11 and 12, and that which Tissandier succeeded in traversing in 1884, fig. 9. When the officers at Chalais undertook the construction of their dirigible balloon, the principal question was as follows: The motors would give 10 ft. velocity, which was insufficient, since that of the wind was

above it at least once out of five times; then they had not yet succeeded in avoiding collapsing, and making it obey the rudder so as to insure certainty of travel. In what conditions, then, did they leave the problem? The speed reached 28 ft.; the balloon obeyed with marvellous docility without turning about; it made its evolutions like a well-constructed boat upon the surfac of tranquil waters.

In this work, which will remain one of the finest examples of careful construction and investigation of our century, it is well to indicate the special part taken by each of the two fellow-workmen. The execution of the programme and the examinations which it required were made together. The study of the arrangement of the suspending sheet; the determination of the volume of the balloon; the arrangement made for insuring the longitudinal stability of the balloon; the calcu-

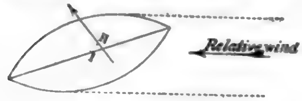


FIG. 16.

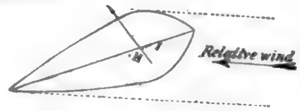


FIG. 17.

lations of the dimensions given to the pieces of the car, and, finally, the invention and construction of a new battery of an exceptional lightness and power, which constitute one of the essential parts of the system, are the personal work of Commandant Renard. The different details of the construction of the balloon, its method of attachment to the sheet, the system of construction of the screw and the rudder, an examination of the electric motor, calculated according to the new method based upon preliminary experiments, permitting them to determine all the elements of a given force, are the works of Krebs, who, thanks to especial arrangements, has succeeded in bringing about the construction of this apparatus under conditions of unexpected lightness.

What remains now, then, to make the steering of balloons really practical? It is necessary to double the speed that has as yet been obtained by increasing the volume and reducing the resistance, or raising the efficiency of the screw, which in the balloon *La France* was only passable, and especially in searching out a motor which will leave the one which has led so far toward success far in the rear.

We assert that this new arrangement has not yet been made. Separated from his fellow-workman, actually Commandant Engineer of the Corps of Pompiers, Commandant Renard has finished the task which they pursued at first in common. His researches have led him to invent an excellent motor which really accomplishes this, and which will weigh, carburetter and accessories included, one and one-half times less than the motor which was used in *La France*. Furthermore, instead of being exhausted in one and one half hours' running, it can work for 12 hours. By the improvements effected in different portions of the balloon, a speed of 36 ft. per second will probably be obtained with this motor. The new dirigible balloon, which will bear the name of *Meusnier*, will then be able to travel with an average s eed of 24.85 miles per hour, which is equal to that of ordinary passenger trains. It has a volume of 120,077 cub. ft. Under these conditions we find that the length in which it is geometrically similar to *La France* will become

$$50.4 \sqrt[3]{\frac{1.861}{3.400}} = 205 \text{ ft. } 8.6 \text{ in.};$$

but it will be 229 ft. 7.8 in. long; the elongation will exceed that of *La France*, perhaps even that of the second Giffard balloon. A housing will carry, by means of suspension and balancing cords, the car, 131 ft 2.9 in. long, which will be made of bamboo and stringers of hollowed-out pine with stays of hollow steel. The screw will be 29 ft. 6.3 in. in diameter, and will make 200 turns per minute. After General Meusnier other apparatus equally progressive over the preceding ones will be made. What I wish to examine now are the means of accomplishing this advancement.

The first quality necessary to realize it is the certainty of route, as well as quickness of manœvring. Without this quality all others will be of no effect, and the balloon will be found in the situation of a deaf mute, who feels the floods of eloquence existing within him. Such was especially the case with the Giffard balloon. I have carefully enumerated the conditions which it is necessary to fulfill, and I have said how they were realized at Chalais. The balloons conceived on the same principles will be quite amenable to the power of their motor.

Their value will then be measured by the obtainable speed. In order to obtain the speed V, it will be necessary to combine the net, the car, the propeller, and the motor, so that

$$\frac{Tr}{R} = V.$$

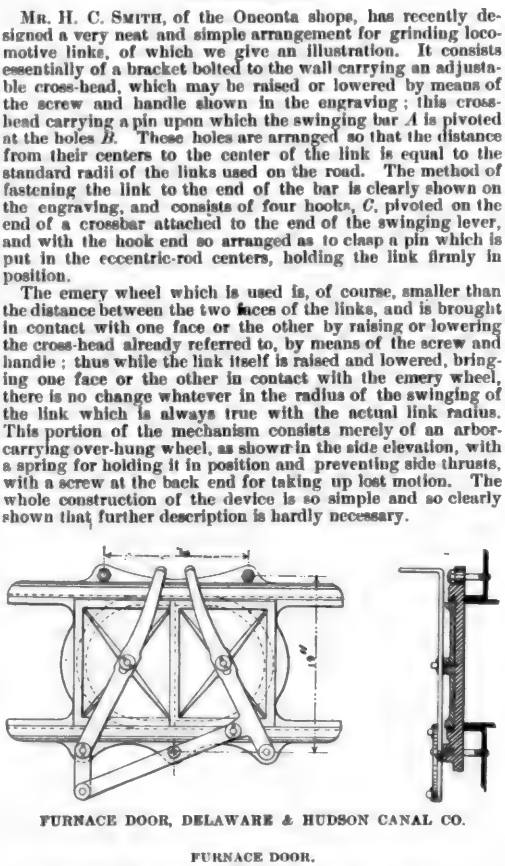
T being the power delivered to the shaft of the machine, R the resistance to advancement which corresponds to the speed V, r the coefficient of reduction between the tractive work and the work on the shaft. This coefficient is a function of the efficiency of the screw of the intermediate working parts. The values of R and of r are both dependent on the action of the air upon the surfaces.

SPECIAL TOOLS OF THE DELAWARE & HUDSON CANAL COMPANY'S SHOPS.

LINK GRINDER.

MR. H. C. SMITH, of the Oneonta shops, has recently designed a very neat and simple arrangement for grinding locomotive links, of which we give an illustration. It consists essentially of a bracket bolted to the wall carrying an adjustable cross-head, which may be raised or lowered by means of the screw and handle shown in the engraving; this cross-head carrying a pin upon which the swinging bar A is pivoted at the holes B. These holes are arranged so that the distance from their centers to the center of the link is equal to the standard radii of the links used on the road. The method of fastening the link to the end of the bar is clearly shown on the engraving, and consists of four hooks, C, pivoted on the end of a crossbar attached to the end of the swinging lever, and with the hook end so arranged as to clasp a pin which is put in the eccentric-rod centers, holding the link firmly in position.

The emery wheel which is used is, of course, smaller than the distance between the two faces of the links, and is brought in contact with one face or the other by raising or lowering the cross-head already referred to, by means of the screw and handle; thus while the link itself is raised and lowered, bringing one face or the other in contact with the emery wheel, there is no change whatever in the radius of the swinging of the link which is always true with the actual link radius. This portion of the mechanism consists merely of an arbor-carrying over-hung wheel, as shown in the side elevation, with a spring for holding it in position and preventing side thrusts, with a screw at the back end for taking up lost motion. The whole construction of the device is so simple and so clearly shown that further description is hardly necessary.

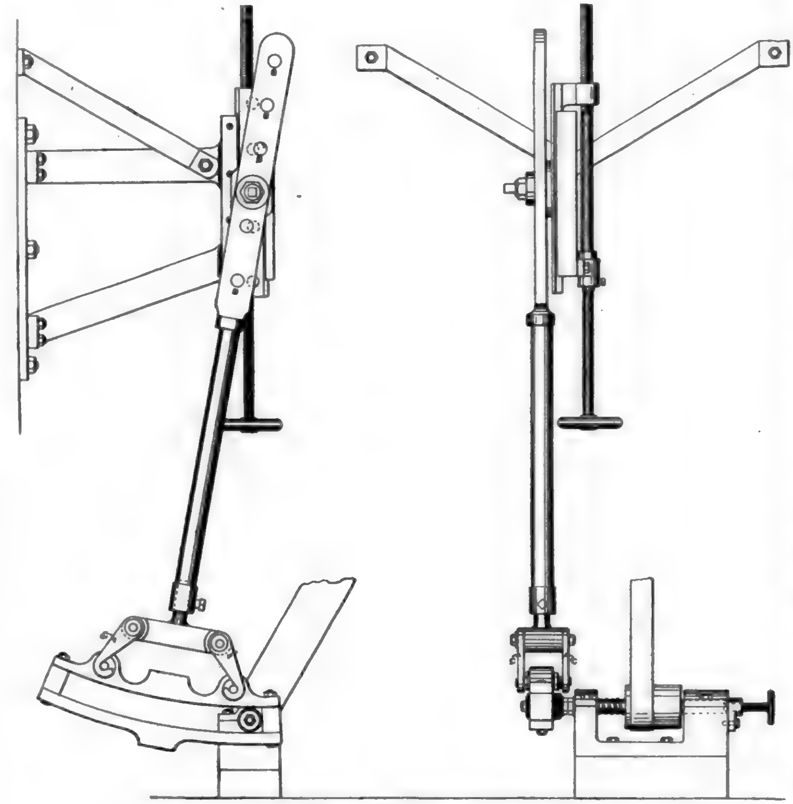


FURNACE DOOR, DELAWARE & HUDSON CANAL CO.

FURNACE DOOR.

The standard furnace door used on all of the engines of the road is shown by the accompanying engraving. It consists of a framework setting around the furnace opening into which two sliding doors are set, which are operated by levers in such a way that whether the top end of either handle is moved outward, both doors open an equal amount from the center. This enables the engineer to assist the fireman in opening his doors when it is necessary, and also provides the fireman with facilities for opening the door with a scoop instead of throwing it open with his hand. As first built, only one of these handles was carried to the top of the door, but in later constructions it has been modified in accordance with the drawing. One of the many advantages of this door is that it has

no tendency to close under the action of the blast, and where an engine is steaming too rapidly, or it is desirable to admit a current of air into the fire-box over the coal, the door can be opened to any extent and left so without danger of its being blown shut. This is, of course, very much better than opening the ordinary door and setting it on the latch, and it also has the advantage of enabling the opening to be made to any desirable extent. The chief dimensions of the door are given in the engraving, and its construction will be very readily understood. This is the same door which is used very extensively in Germany, except where they still have but one handle rising to the top of the door.



LINK GRINDING MACHINE, DELAWARE & HUDSON CANAL CO.

OIL-BOX JACK.

The hydraulic oil-box jack illustrated is a very handy little tool and of simple construction. The total height over all is 9¼ in. The pump is operated by means of a toothed sector and rack, the former being given a partial rotation by a lever outside of the jack itself. The valve arrangements are shown in the vertical section. As the ram works up and down, the suction-valve and delivery-valve are operated as in an ordinary pump, but when it is desired to lower the lifting ram the lever is turned down, so that the side of the sector comes in contact with the stem of the relief-valve pressing it in and allowing the liquid to flow directly from the cylinder of the lifting ram into the reservoir in which the sector and the rack work.

The packing is of the ordinary U-shaped leather packing, and is located as shown in the engraving. Just above this there is a leakage ring, so that any liquid which escapes past the leather packing is caught by it and returned to the reservoir. A filling tube is located on one side, by means of which the waste from the reservoir can be replaced without taking off the cap. The handle, as shown on the side elevation, enables the jack to be readily carried and handled.

THE MIDDLESBROUGH SALT INDUSTRY.

Discovery at Middlesbrough.—Like so many discoveries, knowledge of the existence of the Middlesbrough salt bed came about by means of operations undertaken with quite another object. In 1859–62 Messrs. Bolckow, Vaughan & Company, having bored to a depth of 1,200 ft. on the south bank of the Tees in search of water, discovered a bed of rock salt 100 ft. thick. Shortly afterward they endeavored to sink a shaft, with a view to working the mineral as a rock salt mine. The influx of water, however, proved to be so serious that after heavy expenditure the attempt was abandoned. In 1874 Messrs. Bell Brothers sank a borehole at Clarence, on the north side of the river, and found the salt at 1,127 ft. There the matter rested until 1881, when Sir Lowthian Bell's brother, Mr. Thomas Bell, proposed a method of winning the salt by using one and the same well for sending water down to the salt bed and for pumping up the saturated solution, the fresh water going down the annular space between the larger external tube which formed the lining of the well, and the smaller central tube through which the brine was pumped up. Although Mr. Bell was not aware of the fact at the time of proposing this method, it was then already in operation in France, and after a visit to the French works Messrs. Bell sank a well of suitable size, constructed evaporating apparatus, and in 1882 began making salt. To Messrs. Bell Brothers, therefore, belongs the honor of having been the pioneers of this important industry.

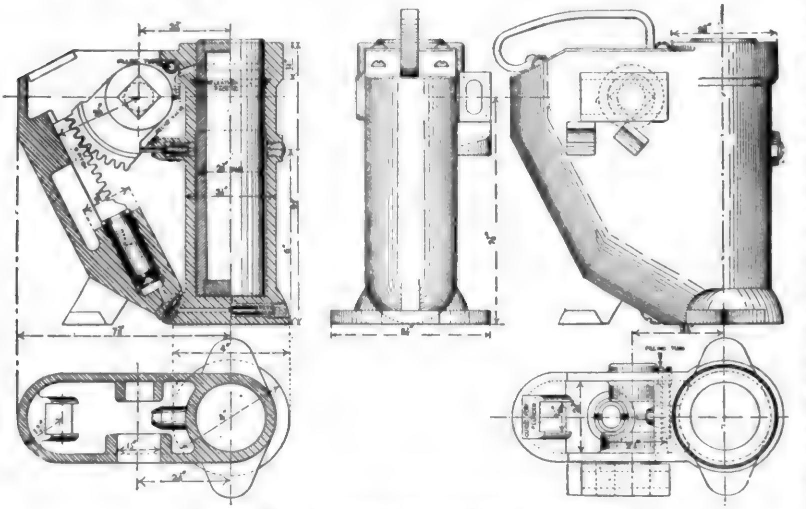
Extent of Deposit.—The bed of rock salt, so far as now proved, extends over an area of about five miles long from west to east, by four miles wide from north to south, or about 20 square miles. Each square mile is estimated to contain 100,000,000 tons of salt; and although, by any method which now appears likely to be adopted, a proportion probably not exceeding 25 per cent. of the whole can ever be brought to the surface, yet the figures are so large that the question of possible exhaustion of supply need not be taken into account. The most northerly borehole is near Greatham, where the bed of salt was found at the depth of 889 ft., and is 57 ft. thick; the most southerly is at North Ormesby, where it was found at 1,340 ft., and is 79 ft. thick; the most easterly at Lackenby, the bed being met with at 1,685 ft., and 119 ft. thick; and the most westerly at Sandfield, Haverton Hill, where the bed occurs at the depth of 797 ft., and is 80 ft. thick. The thickness of the bed varies considerably, but the average may be taken at 80 ft. to 90 ft.

Analysis.—It is difficult to give an average analysis of the bed, owing to difference in proportion of marl mixed with the salt. Samples are obtained showing as high as 98 per cent. of sodium chloride, and as low as 45 per cent.

Brine.—The British productions of salt amounts to about 2,000,000 tons per annum, of which 90 per cent. is white salt made from brine. The balance of 10 per cent. is mined chiefly in Cheshire as rock salt; it is of dark-red color, and is suitable only for purposes where a high degree of purity is not essential. All the salt made near Middlesbrough is made from brine by evaporation. Fully saturated brine contains 26¼ per cent.

of salt; a fair working strength may be roughly taken at 25 per cent.

In Cheshire the brine is formed by surface water finding access to the rock salt, quickly becoming fully saturated, and then flowing for long distances through crevices or "runs" to the point where it is pumped up. Brine so formed is called "natural brine," and has the enormous advantage of being so abundant that it can be raised at the lowest possible cost by means of large and powerful pumps. As its saturation takes place far away from the pumping station, no disturbance of foundations occurs at the latter through abstraction of the mineral beneath, although much-tried farmers, miles away, find their fields subsiding, until small lakes, having steep and broken sides, are formed. Meanwhile, at the pumping station the brine is abundant, strong, cheap, and pure; for in its long and gradual course underground insoluble particles held in suspension become precipitated. The Cheshire salt industry, therefore, enjoys the advantage of an ideal position, so far as getting the brine is concerned; and when the salt produced has been conveyed some 30 miles by canal, it commands the tonnage of Liverpool for its export. The disadvantage lies, of course, in the 30 miles of canal, which is navigated by means of steam barges carrying about 250 tons, each of which tows a string of smaller barges. These enter any dock in which the ship requiring the salt is lying; and they are admirably fitted for rapidly putting their cargoes on board.



OIL-BOX JACK, DELAWARE & HUDSON CANAL CO.

Boring of Wells.—At Middlesbrough, as already stated, brine is obtained entirely by boring deep wells. Up to 1886, with two exceptions, these were all bored by the Cumberland Diamond Boring Company, using the diamond boring process, which is familiar to engineers. A number of black diamonds are fixed with their cutting edges projecting from the end of a short tube, called a crown, which is screwed on the bottom of a core tube about 18 ft. long, and varying in diameter according to the size of the well to be bored. The whole is rotated by hollow rods, through which a pressure of water is maintained. By this means a solid core is obtained, and the process is therefore valuable for prospecting; but the large sums charged for the wells bored in this way, together with the cost and slowness of repairing them, were threatening to destroy the salt industry at Middlesbrough altogether, when Messrs. Tennant & Partners obtained information which led to the introduction of the method of drilling practised in the American oil regions, where a large number of wells have been put down, and valuable experience obtained. The success of this method was immediate and complete; wells 1,000 ft. deep were sunk in three weeks instead of as many months, with a corresponding reduction in cost. It completely superseded the diamond boring, and was found so much more efficient for repairing holes, as well as for the original drilling, that not one of the 55 wells now in operation at Middlesbrough is without its derrick and American apparatus.

Free-falling Tools.—Drilling is effected by the use of free-falling tools, suspended by a cable. The weight of the tools being about 18 cwt., and the height of fall about 3 ft., blows are given of sufficient force to pierce the hardest rock. The face of the chisel being blunt, the drillings are pounded to powder, and mixed with water in the hole. After drilling from 3 ft. to 5 ft. depth, the tools are rapidly withdrawn, and a sand pump attached to a separate rope is let down in order to remove the detritus, after which the tools are again used.

Derrick.—The "rig," as it is called in America, bears evidence of having been developed in a country where wood is plentiful; and its rough-and-ready character often excites the surprise and disapproval of English engineers. But "handsome is that handsome does," and respect for the rig grows with knowledge of what can be effected by its use in skilful hands. It consists of a derrick 74 ft. high, 20 ft. square at the base, and 3 ft. at the top, surmounted by a crown pulley, over which passes the drilling cable or tubing rope, and a snatch block for the sand-pump line. A bull wheel and drum, driven by an endless rope which is rapidly thrown on or off as required, takes the coil of drilling cable for lifting or lowering tools or tubes. A walking beam, attached at one end to a crank, gives the necessary motion to the drilling tools, and afterward to the pump rods. The crank has a throw of 2 ft., giving a stroke of 4 ft. to the end of the beam, to which the drilling cable is attached by means of an adjustable screw; each revolution of the crank thus produces one blow of the drilling tools. The reel carrying the sand-pump line is worked by a friction pulley. The whole work is done by two men. The driller standing by his tools has within reach the "telegraph line" for controlling the engine; the reversing line attached to the link motion on the engine; the sand-reel lever controlling the sandpump line; and the brake on the bull wheel, which controls the drilling cable and tools.

Drilling Tools.—The tools used consist of a chisel or "bit," stem 32 ft. long, jars, sinker bar 10 ft. long, and rope socket. These are called a "string of tools," and are altogether about 60 ft. long. They are connected by taper screw joints. This joint gives great strength; a few turns bring it home, and an arrangement of levers screws it up so tightly that it does not often unscrew in use, notwithstanding the vibration to which incessant blows subject the tools. The jars are a pair of links having a vertical play of 9 in.; they are for the purpose of freeing the tools if jammed or fastened in any way, by enabling the driller to give a succession of upward blows which loosen the tools, no matter how firmly they may be held. The temper screw is an ingenious contrivance for attaching the cable to the walking beam, and enables the driller to slacken or tighten the cable, and to cause the tools to revolve when drilling. What can be effected by these appliances in the hands of a highly skilled driller is little short of the marvelous. Holes have been drilled nearly a mile in depth, perfectly straight and perfectly round. In Austria, indeed, a hole is reported to have been drilled to a depth of over 6,000 ft.; but the deepest American hole, at Pittsburgh, is 4,618 ft.

Accidents.—The driller's only knowledge of the tools while in the borehole is through the cable, which his hand never leaves while drilling. Extraordinary complications sometimes arise; a faulty joint may unscrew or a tool break, the upper end of which may be driven quite aside from the line of the hole. In the effort to recover it, other tools may be lost, until perhaps a ton of iron blocks the well. On all this a "run in" may occur, burying the whole possibly 100 ft. deep, and at 1,000 ft. or more below the surface. With patient and wonderful skill the hole is cleaned out, tool after tool withdrawn, and the cause of the mischief straightened up and got out. Or the hole may collapse, burying the tools and "sticking" the jars. Then the cable is cut at the lowest accessible point; the hole is lined with tubes, which follow the tools down; the buried tools are got hold of, and by the action of jars are drawn

out inch by inch. Sometimes, though rarely, holes have to be abandoned as the result of such accidents.

Sinking and Lining of Middlesbrough Wells.—The diameter of the Middlesbrough wells is 8 in. After construction of the rig, the first process is to drive down 10-in. tubes, furnished with a strong shoe, through the surface clay, sand, gravel, etc., to a depth of from 80 ft. to 130 ft., till the sandstone is reached; for which purpose the rig is temporarily transformed into a clumsy-looking but efficient pile driver. After this the drilling begins. Thicknesses of from 300 ft. to 700 ft. of water-bearing red sandstone are passed through, then red marl down to the white stone overlying the salt, then rotten marl, and then the salt bed; the drilling stops at the bottom of the salt. The 8-in. hole is then lined, either throughout from top to bottom, or else only through the bottom 200 ft., which is the region of falls of marl. For this bottom portion ½-in. tube is used of 5¼ in. bore. If the hole is lined higher up, the tubes are ¼ in. thick and 6¼ in. bore; at the couplings they are then 7¼ in. in diameter outside.

Pumping of Brine.—As soon as the well is bored, the pump tubes in place, and the pump rods attached, the small cavity occupied by the well in the salt bed will be filled with fully saturated brine; and the pump being started at the normal speed of 12 to 14 strokes per minute, the first discharge will be water, until the brine, passing up the suction pipe, appears in a muddy stream. It quickly clears, and as quickly becomes weak, through the exhaustion of the contents of the cavity, which is as yet small. Water is found in the sandstone within 20 ft. of the surface, and, standing in the annular space, balances the column of brine so far as the difference in their specific gravity permits. A column of water 1,200 ft. supports one of brine having a height of nearly 1,000 ft.; the pump, therefore, has really to lift the brine only about 200 ft. A new well, if working properly, increases daily in yield as the cavity in the salt bed becomes enlarged through the removal of salt, and thereby presents a larger area of salt surface for solution. Owing to its greater specific gravity, the strongest brine is always found at the bottom of the well; and if the pumping is considerable, brine of decreasing strength, or even fresh water, will occupy the upper part of the cavity. The solvent power of the water, of course, steadily becomes less as full saturation is approached, until it ceases altogether. The result is that more salt is removed from the top of the bed than from lower down; and thus the shape of the cavity should become that of a flat funnel or shallow inverted cone, depending somewhat on how the well is pumped, whether so fast as to yield weak brine or not. This has proved to be what really happens. Wells bored at from 40 to 60 yards distance from old wells have found the cavity already formed and of a depth which, considered in relation to the salt removed, confirmed this theory. In another case a fall of rock broke the well tubes. The fallen stone was drilled through, and fresh tubes inserted to the cavity beneath it. After the pumping had been resumed, the stone slipped down 1½ ft., breaking the tubes again. It was again pierced and the process repeated until the stone was lowered 6 ft., showing that solution of the supporting side of the funnel had allowed the stone to slip down. The pumper confessed defeat, and now pumps from the top of the stone; but he bides his time in the belief that science will eventually provide an explosive which shall create a sufficient disturbance in the very heart and vitals of that obdurate stone. Last, but perhaps not least, an abandoned cavity at Nancy having been pumped dry, was entered, and found to be of the shape indicated. It is obvious that the funnel shape of the cavity is an important matter, and an unfortunate one, for pumping, because it removes support from the neighborhood of the tubes, where it is most needed: and heavy falls of marl and rock occur, which break the tubes, no matter how strong they are, although light falls may be resisted and are known only by the discoloration of the brine. Half-inch steel lining tubes are used; and with this thickness the worst bent and broken tubes after a fall have, with great strain and difficulty, been so far straightened as to be got out by a steady pull with two 50-ton jacks; but in a well with ¾-in. steel tubes the bend was such that withdrawal was impossible, and the well had to be abandoned. After a fall, weak brine or water is obtained; the invaluable rig is detached from the pumping gear, and is used to withdraw the tubes above the break, generally leaving from 60 ft. to 100 ft. in the well. The tools are then strung up, and an attempt is made to drill down by the side of the old tubes, and to put fresh tubes in. This operation is often attended with endless perplexities and difficulties; nevertheless, wells have been repaired in this way many times. Tools are often lost in this cleaning-out process; in one instance a string of tools, cable and all, went down a cavity, and remain there; and yet the well is working still. The number of wells which have been pumped and afterward abandoned for various reasons is believed not to exceed ten.

Yield and Strength of Brine.—Wells vary considerably, both in yield and in strength of brine. This may be due to the existence of earthy matter, which may cover the salt with a coating of mud, and thus check solution; or it may be due to defective couplings or tubes, which would permit dilution of the brine by the entrance of water into the pump tubes from the annular space surrounding them. A well pumping 10 hours per day, and yielding 200 tons of salt in brine per week, would be considered doing good work.

Surface Subsidence.—The question of possible subsidence of the surface has naturally excited a good deal of interest in Middlesbrough. In Cheshire the flooding of old rock-salt mines and the subsequent pumping, as well as the removal of the mineral from the course of the "runs," have led to serious subsidence, and to extraordinary behavior on the part of houses, roads, streams, and bridges; but at Middlesbrough the depth of the salt bed is so much greater, and the character of the strata so different, that it does not follow the same results will occur. It is believed that great arches will form themselves over the funnel-shaped cavities in the rock-salt, from point to point of support; or that the interstices left by broken masses of fallen rock will equal the bulk of salt removed, and will so support the surface. On the other hand, it is the opinion of experienced persons in Cheshire that subsidence will ultimately take place; and to this result the experience of mining engineers seems to point. All that can so far be said with certainty is that no sign of subsidence has yet shown itself.

Filtration and Evaporation of Brine.—On reaching the surface the brine is conveyed in pipes to a filter bed, constructed on the pattern of ordinary waterworks sand filters. These act well, and pass a clear bright brine to the reservoir, whence it is pumped to the pans for evaporation. Notwithstanding the fact that endless efforts have been made to improve the method of evaporation, and that a large number of plans have been devised for this purpose, yet to-day, just as 1,800 years ago, open pans are used, having heat passed under them. The only difference is that the Romans used pans made of lead, and not more than a few feet square; while to-day much larger pans, made of steel and iron, are employed. The ordinary size of common salt pans is 60 ft. × 24 ft. × 1½ ft. deep. The pans are set upon longitudinal walls, which form flues to convey the products of combustion from fireplaces at one end of the pan to the chimney at the other. As the water is driven off by evaporation, the salt crystals form on the surface of the brine, and gradually sink to the bottom. They are drawn by rakes to the side of the pan, and lifted out and deposited upon decks or "hurdles," from which the adhering brine drains back into the pans.

Salt.—Fine salt is obtained from salt which is boiled, the fineness of grain depending upon the temperature at which the brine is evaporated—the higher the temperature, the finer the grain; the lower the temperature, the larger the crystals. Block salt or "squares" are obtained by drawing off boiled salt at short intervals into moulds; the squares are afterward dried by surplus heat from the pans. Table and dairy salt are obtained by grinding squares. Common salt is drawn every other day from brine kept at about 190° F.; fishery is drawn every 7 or 14 days, according to grain, from brine kept at about 100°. All these processes are very simple, yet the salt manufacturer is not without his difficulties and perplexities; and a certain degree of skill and good management is essential to the successful prosecution of this, as of every other industry.—*Practical Engineer.*

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(Continued from page 449.)

No. 17 flying machine of M. *Hargrave* is described in his twelfth communication to the Royal Society of New South Wales, read August 3, 1892. The total weight of the apparatus is 64.5 oz., or 4.03 lbs., including 12¾ oz. for the strut and body plane, so that the engine and boiler, including 5 oz. for spirit fuel and water, weighs 3.25 lbs., and develops 0.169 horse power, or at the rate of 19.2 lbs. per horse power—a very remarkable achievement.

The boiler is of the "Serpollet" type, made of 12 lineal feet of ½ in. copper tubing (steel pipe could not be got in Sydney), in the form of a double-stranded coil, encased in

asbestos, and placed just over the backbone of the apparatus. The fuel is methylated spirits of wine, drawn from a tank placed above the boiler, vaporized, mixed with air and spurted into the furnace. As much as 6.9 cub. in. of water have been evaporated by 1.7 cub. in. of spirit in 80 seconds, making 182 double vibrations of the propelling wings, say, 2.35 per second, and developing 0.169 horse power.

It was estimated that if the apparatus were loaded with 10 oz. more of spirit and water, and thus made to weigh the same as the compressed-air machine No. 12, which flew 343 ft., then the steam apparatus No. 17 would possess a sufficient store of energy to fly 1,640 yds., or nearly 1 mile.

But M. *Hargrave* has done still better, for in March, 1893, he prepared a paper, which was presented to the Conference on Aerial Navigation at Chicago, August 2, 1893, in

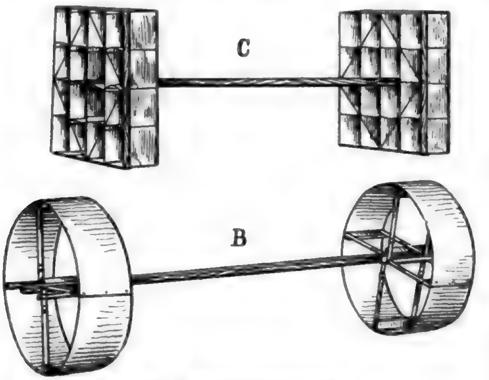


Fig. 80.—HARGRAVE—1893.

which he gave data concerning his No. 18 flying machine. This apparatus is also driven by a steam-engine which weighs, with 21 oz. of fuel and water, an aggregate of 7 lbs., and indicates 0.653 horse power, or at the rate of 10.7 lbs. per horse power; so that, roughly speaking, the weight of the motor has been doubled, and the power has been increased fourfold.

Four boilers were constructed. The final one was made of 31 lineal feet of ¼ in. copper pipe, with an internal diameter of 0.18 in., and arranged in three concentric vertical coils whose diameters were 1.6 in., 2.6 in., and 3.6 in. respectively. It weighed 37 oz., but it is now known "that a coil of equal capacity can be made weighing only 8 oz., and still excessively strong." The cylinder is 2 in. diameter, with a stroke of 2.52 in. The feed-pump ram is 0.266 in. diameter, and the piston valves 0.3 in. diameter. On one occasion this motor evaporated 14.7 cub. in. of water with 4.13 cub. in. of spirit in 40 seconds. During a portion of the time it was working at a speed of 171 double vibrations per minute.

M. *Hargrave* gives no data concerning the flight of his last two (steam) machines. He states that 11 different burners have been tried, and that the flame striking the water boiler first has a tendency to vary the supply of heat to the spirit holder. From this it is inferred that he is struggling with the same difficulties already encountered by *Stringfellow*, by *Moy*, and by *Maxim* in regulating and keeping alight spirit burners when the apparatus gets under forward headway; but this difficulty, while a serious one, will doubtless be eventually overcome by persistent experiment, and we may then expect flights of astonishing lengths.

Seeing now his way to an adequate motor and to extensive flights in the near future, M. *Hargrave* recently turned his attention to experiments upon curved surfaces, and to the seeking for a better disposition of the sustaining surfaces or body planes. He had described the eccentricities of a curved strip in the form of a segment of a hollow cylinder, when exposed to the wind, in his paper No. 12 to the Royal Society of New South Wales, read August 3, 1892, and he describes some of his experiments with "cellular kites," in his paper read in the Aerial Navigation at Chicago, August 2, 1893.

The "cellular kites" constitute quite a new departure, and practically consist of superposed aeroplanes connected together in pairs. *B*, in fig. 80, shows the simplest form. This consisted in two hollow cylinders of aluminium, each 13 in. diameter by 4¾ in. deep, mounted 30 in. apart upon a connecting stick, and weighing 14¾ lbs. The kite-string was attached 11 in. back from the forward section, and as a consequence of the angle of incidence thus produced, the apparatus mounted upon the wind. Its particular behavior is not described in the paper. *C*, in fig. 80, shows a kite with 16 cells, the length of each being 3 in., by a height of 3 in., and a breadth of 8 in. It was made of cardboard, and the two sections were 22 in. apart, the point of attachment of the kite-string being 6¼ in. distant from the forward section, while the weight was 10.5 lbs. This seems to indicate that this kite flew at a steeper angle than the preceding, although we should expect the reverse, in consequence of the greater proportion of sustaining surface. M. *Hargrave* says, "These kites have a fine angle of incidence, so that they correspond with the flying machines they are meant to represent, and differ from the kites of our youth, which we recollect floating at an angle of about 45°, in which position the lift and the drift are about equal. The fine angle makes the lift largely exceed the drift, and brings the kite so that the upper part of the string is nearly vertical."

Kites *E* and *F*, fig. 81, are of exactly the same size and weight, consisting of one cell, 4 in. long, 10.7 in. broad by 6.25 in. high, constructed of wood and paper, and weighing 3.25 lbs.; the two sections are 21.25 in. apart, and the string is fastened 7.25 in. back of the forward section. The only difference is that kite *E* has its horizontal (top and bottom) surfaces curved to a radius of 4.5 in., while all the surfaces of kite *F* are true planes. The result is that when kite *E* is flown with the convex sides up, it pulls about twice as hard on the string as kite *F*, so that, as M. *Hargrave* says: "A flying machine with curved surfaces would be better than one with a flat body plane, if the form could be made with the same weight of material."

M. *Hargrave*, in this last paper, figures and describes two other forms of cellular kites with which he has experimented, and points out that the rectangular form of cell is collapsible when one diagonal tie is disconnected, so as to make it easy of transportation. He says: "Theoretically, if the kite is perfect in construction and the wind steady, the string could be attached infinitely near the center of the connecting stick, and the kite would fly very near the zenith. It is obvious that any number of kites

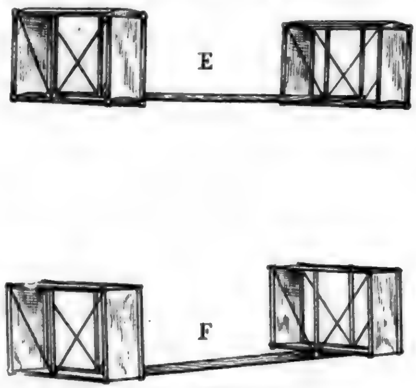


Fig. 81.—HARGRAVE—1893.

may be strung together on the same line, and that there is no limit to the weight that may be buoyed up in a breeze by means of light and handy tackle. The next step is clear enough—namely, that a flying machine with acres of surface can be safely got under way, or anchored and hauled to the ground by means of the string of kites."

He duly gives credit to M. *Wenham* for suggesting the superposition of planes in 1866, and it is an interesting circumstance to note that at the same Chicago conference, a

paper from M. *Wenham* was read suggesting a course of experiments with kites, to determine the best arrangement of superposed aeroplanes and the conditions of equipoise.

Such are the labors of M. *Hargrave* up to the present time. He no longer troubles himself about the general problem of man's eventual success in navigating the air, but he says: "The people of Sydney who can speak of my work without a smile are very scarce; it is doubtless the same with American workers. I know that success is dead sure to come, and therefore do not waste time and words in trying to convince unbelievers."

Instead of this, he constructs machines and reports the results in detail, so that others may repeat his experiments. He says that the record of unsuccessful experiments takes up a considerable portion of his notes, and further, that "there is no use in the mind's conceiving an idea, if the hands are not ready to carry out the work skillfully, in the absence of reliable assistance, and if the design be found faulty, the whole thing should be begun again without trying to use up old machines. The question of intricate workmanship and costliness is being continually battled with; my constant endeavors are directed to making the machines simple and cheap, so that any one who doubts can verify my work, provided his hands are as skillful as mine, and I am sure that the photographs show clearly that the workmanship is anything but first-rate."

He began with small, cheap models, and has gradually enlarged their size, and obtained flights longer than any heretofore accomplished. It is noticeable that the heavier the model, and the smaller the sustaining area in proportion to the weight, the more successful has been the flight. He may not be the first man to ride at will upon the air, but he deserves to succeed.

In November, 1890, M. *Hiram S. Maxim*, the celebrated American inventor of a writing telegraph, of several systems of electric lighting, and of the "Maxim automatic machine gun," addressed a letter to the New York *Times*, in which he stated that, before sailing back to England, he thought it would be well to state what he was doing toward constructing a flying machine which had been alluded to lately by the American press. Among other things he said:

I would say that among the large number of societies to which I belong in England, the Aeronautical Society is one, and need I say that I am the most active member? At the present moment experiments are being conducted by me at Baldwin's Park, Bexley, Kent, England, with a view of finding out exactly what the supporting power of a plane is when driven through the air at a slight angle from the horizontal. For this purpose I constructed a very elaborate apparatus, provided with a great number of instruments, and arranged in such a manner that I can ascertain accurately the efficiency of a screw working in air, the amount of power required to drive a screw, the amount of push developed by a screw, the amount of slip, and also the power required for propelling planes through the air when placed at different angles, as well as to ascertain the friction and all other phenomena connected with the subject. I have been experimenting with motors and have succeeded in making them so that they will develop 1 horse power for every 6 lbs. My experiments show that as much as 133 lbs. may be sustained in the air by the expenditure of 1 horse power; of course, it is premature now to express any opinion; still, if I am not very much mistaken, and if some new phenomenon, which I do not understand, does not prevent it, I think I stand a fair chance of solving the problem, and I think I can assert that within a very few years some one—if not myself, somebody else—will have made a machine which can be guided through the air, will travel with considerable velocity, and will be sufficiently under control to be used for military purposes. I have found in my experiments that it is necessary to have a speed of at least 30 miles per hour, that 50 miles is still more favorable, and that 100 miles would seem to be attainable. Everything seems to be in favor of high speed.

Whether I succeed or not, the results of my experiments will be published, and as I am the only man who has ever tried the experiments in a thorough manner with delicate and

FIG. 82.—MAXIM—1893.

accurate apparatus, the data which I shall be able to furnish will be of much greater value to experimenters hereafter than all that has ever been published before.

In May, 1891, M. *Maxim* again visited the United States, and he gave to various newspaper reporters, notably to one from the New York *Sun*, some particulars concerning the flying machine, or "first kite of war," which he was building in England, and upon which he had spent up to that time (including the preliminary experiments) some $45,000.

He described the apparatus with which he had made his preliminary experiments, to ascertain accurately the supporting power and resistance of air to aeroplanes at small angles of incidence, and then continued as follows:

My large apparatus is provided with a plane 110 ft. long and 40 ft. wide, made of a frame of steel tubes covered with silk. Other smaller planes attached to this make up a surface of 5,500 sq. ft. There is one great central plane, and to this are hinged various other planes, very much smaller, which are used for keeping the equilibrium correct, and for keeping the flying machine at a fixed angle in the air. The whole apparatus, including the steering gear, is 145 ft. long. . . . A part of the aeroplane, or actual kite, is made of very thin metal, and serves as a very efficient condenser for the steam. . . .

It is ready and awaiting my return. It is now resting on a track 12 ft. wide and half a mile long, in my park. The first quarter of a mile of the track is double—that is to say, the upper track is 3 in. above the lower. By that means I am able to observe and measure the lift of the machine when it starts, because the upper track will hold it down when it lifts off the lower one. When completed the machine will weigh, with water tanks and fuel, somewhere between 5,000 lbs and 6,000 lbs., and the power at my disposal will be 300 horse power in case I wish to use it; but it is expected that about 40 horse power will suffice after the machine has once been started, and that the consumption of fuel will be from 40 lbs. to 50 lbs. per hour. The machine is made with its present great length so as to give a man time to think; its length makes it easier to steer and to change its angle in the air. Its quantity of power is so enormously great in proportion to its weight that it will quickly get its speed. It will rise in the air like a sea-gull if the engine be run at full speed while the machine is held fast to the track; and if it is then suddenly loosened and let go.

M. *Maxim* very judiciously refrained from furnishing drawings or detailed descriptions of an apparatus which was still in process of evolution, and which he might want to modify as he proceeded in erection and trial. Indeed, it is probable that he has varied considerably from the various arrangements which he has patented from time to time,* so that drawings and descriptions made from these might be wide of the mark.

The important, the vital feature, however, he recognized to be the motor, and to perfecting this he gave his first attention. In steam motors he seems to have accomplished wonderful results, hitherto quite unreached, and in an article published in the *Century Magazine* for October, 1891, after describing and illustrating the experimental whirling machine with which he had gathered his preliminary data, he gives the following account of what he had accomplished up to that time with the motor:

I have come to the conclusion that the greatest amount of force with the minimum amount of weight can be obtained from a high-pressure compound steam-engine, using steam at a pressure of from 200 lbs. to 350 lbs. to the square inch, and lately I have constructed two such engines, each weighing 300 lbs. These engines, when working under a pressure of 200 lbs. to the square inch, and with a piston speed of only 400 ft. per minute, develop in useful effect in push of screws over 100 horse power, the push of the screws collectively being over 1,000 lbs. By increasing the number of turns, and also the steam pressure, I believe it will be possible to obtain from 200 horse power to 300 horse power from the same engines, and with a piston speed no greater than 850 ft. per minute.† These engines are made throughout of tempered steel, and are of great strength and lightness. The new feature about my motors, however, is the manner of generating steam. The steam generator itself, without the casing about it, weighs only 350 lbs.; the engine, generator, casing, pumps, cranks, screw-shaft, and screws weigh 1,800 lbs., and the rest of the machine as much more. With a supply of fuel, water, and three men, the weight will not be far from 5,000 lbs. As the foregoing experiments have shown that the load may be 14 times the push of the screw, it would appear that this machine ought to carry a burden, including its own weight, of 14,000 lbs., thus leaving a margin of 9,000 lbs., provided that the steam pressure is maintained at 200 lbs. to the square inch. The steam generator is self-regulating, has 48,000 brazed joints, and is heated by 45,000 gas jets, gas being made by a simple process from petroleum. When the machine is finished the exhaust steam will be condensed by an atmospheric condenser, made of a great number of very thin metallic tubes, arranged in such a manner that they form a considerable portion of the lifting surface of the aeroplane. The greater part of the machine is constructed from thin steel tubes. I found that these were much more suitable for the purpose than the much talked-of aluminium; still I believe that if I should succeed in constructing a successful machine, it would lead to such improvements in the manufacture of aluminium products that it will be possible to reduce greatly the weight of the machine.

The question of keeping the machine on an "even keel," of steering, and of landing, have been duly considered and provided for, but a description of these would be premature before the machine has actually been tried.

When it is remembered that locomotives weigh some 200 lbs. per horse power, that the lightest marine (launch) engines in 1889 weighed about 60 lbs. per horse power, and that the largest steam-engines previously built for aerial navigation purposes were those of *Giffard* and of *Moy*, each of 3 horse power and weighing (with their boilers) 110 lbs. and 27 lbs. per horse power respectively, then the importance of M. *Maxim's* achievement, as above set forth, may be partially realized; particularly when it is considered that the relative weight tends to increase with the size, and that M. *Maxim's* expectations of obtaining 300 horse power from the same engines have been fully confirmed, as will be seen hereafter.

Moreover, as exhausting the steam into the air would involve carrying a supply of water amounting to some 20 or 25 lbs. per horse power per hour, and this would have been simply prohibitory, M. *Maxim's* plans included a surface aero-condenser, in order that the same water might be used over and over again. This was a wholly unsolved problem, such tentative experiments as had been tried previously by others having indicated weights of 50 lbs. to 150 lbs. per horse power, as necessary for efficient aero-condensers, and this would also have been prohibitory.

M. *Maxim* proposes to solve this problem by making all the frames of his apparatus of hollow tubes, and connecting therewith a condenser consisting of a large number of wide, flat, or film tubes—that is to say, of tubes of thin metal having a flat bore, through which the steam will pass in thin films of considerable width; these film tubes being so arranged that in the forward motion of the machine the air will impinge upon them, thus effectually cooling them and condensing the steam therein. This aero-condenser is utilized as a part or the whole of the sustaining surface, or there may be substituted therefor a large flexible bag or chamber, connected at the forward part with the exhaust steam-pipe, and at the rear end with the hot well, or directly with the suction-pipe of the feed-pump. He relies, of course, upon the increased condensation produced by air currents due to the forward motion of the machine, and the extent of the condenser is therefore a matter for experiment, so that its exact weight cannot be settled in advance.

The horizontal angle of incidence in flight is to be maintained by a "Gyrostat," which consists in a gyroscopic wheel rotating rapidly, suspended by universal joints and connected with two horizontal rudders, one at the front and the other at the back of the apparatus, so as to act upon them instantly (through the well-known property of the gyroscope to continue rotating in the same plane), in case any tendency occurs to deviate from the angle of incidence with the horizon.

The whole of the apparatus is to be thoroughly stayed by diagonal wire ties, so as to make every part rigid and prevent deformations under varying wind pressures.

Fig. 82, engraved from a photograph kindly furnished by M. *Maxim*, exhibits the main features of the apparatus. It does not show the front or back rudders, which have been removed, nor the side wings, set at a diedral angle, to

* British patents Nos. 10,359 and 16,883, A.D. 1889; No. 19,228, A.D. 1891.

† The piston speed of an express locomotive is about 1,000 ft. per minute.

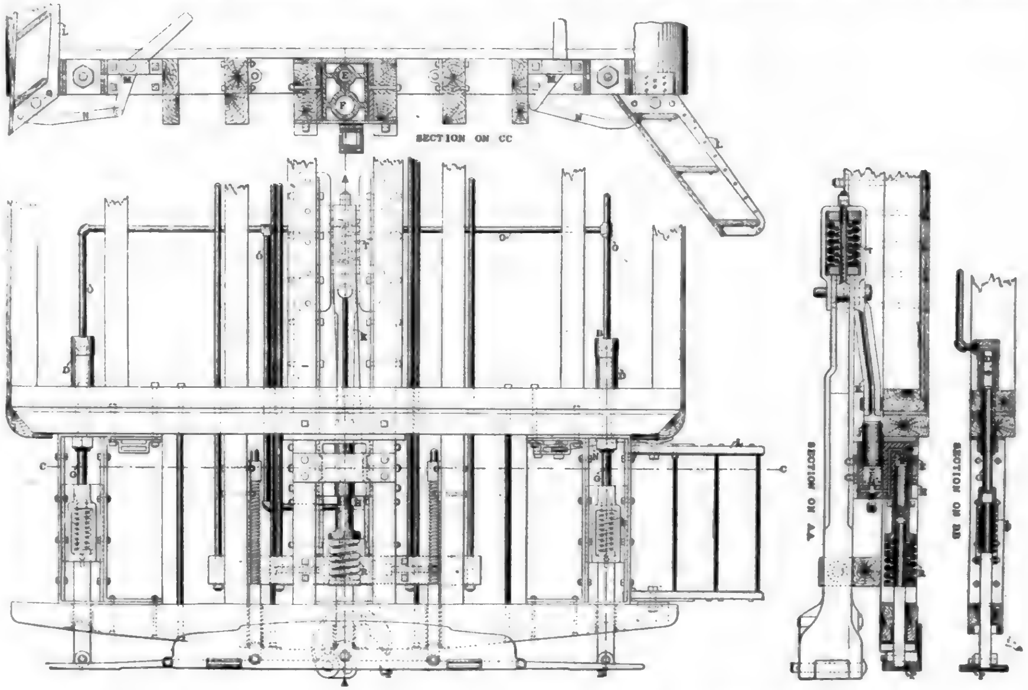
preserve the transverse stability, nor sundry possible keel-cloths or auxiliary planes intended to promote the same object. It exhibits the central or principal aeroplane, with the forward end facing the observer. This main aeroplane is understood to be 50 ft. wide, about 58 ft. long, and slightly concave in the direction of its length, while it is trussed and stiffened in every direction by wire stays. The condenser is indicated by the dark shading at the front of the main plane, and, as will readily be seen, can be largely increased in surface, but, however, at the expense of added weight. The driving screws are placed at the rear, and are understood to be 17 ft. 10 in. in diameter, the speed of rotation varying, of course, with the power exerted.

The whole apparatus is mounted upon wheels, running over a railway track, so as to acquire sufficient speed to rise upon the air, and the three men who are grouped about the front may enable the reader to gather by comparison some general conception of the colossal dimensions of this flying machine.

(TO BE CONTINUED.)

ders F, E, D, D, are all connected to the same system of piping, and the pressure per square inch will be the same in each. This pipe O is connected to a pump and reservoir inside the car. The pipes, cylinder, and reservoir are filled with water or other fluid.

In the ordinary systems of coupling cars used in this country with couplers of the Janney and Miller type, the couplers and buffers are usually so arranged that when the cars are coupled, the springs that force the buffers out are compressed to a certain extent, thus forcing the buffer together and tending to hold the cars steady. The amount of this compression and the subsequent pressure upon the buffers is, however, limited, since in order to effect a coupling the cars must be driven together with sufficient force to compress the buffer springs and allow the couplers to engage. If the springs are too stiff this impact is too great, and will not only damage the cars, but will cause disagreeable shock to the passengers. In some systems the coupler and buffer are so connected by levers or pressure-bars that, as the coupler is pulled forward, the motion is transmitted to the buffer, and the opposing buffers are thus pressed together with greater force. In this case, however, the amount of pressure that can be put on the buffers



LEONARD'S HYDROSTATIC BUFFER.

The object of this buffer is to provide means of holding adjacent cars firmly together, thus increasing the friction between the buffers and lessening the amount of oscillation due to curves and uneven tracks.

In the different views on the drawing the same letter refers to the same part. Two center cylinders, E and F, cast in one piece, are firmly secured between the center sills of the car. The cylinder E is fitted with a ram H, which is forced outward against a cross-head pressing against the spring R, which transmits the pressure to the buffer P. The cylinder F is fitted with a ram J, which is forced against the pressure-bar K. This pressure-bar is secured to the back end of the draw-head. When pressure is admitted to cylinder F by the pipe O, the ram J is driven back and the draw-head is drawn in. At the same time the pressure passes through the port shown to the cylinder E and forces the buffer P outward; thus the cars are drawn firmly together. Two side cylinders D, D, are secured in the end sill of the car. Each of these is fitted with a ram G, which bears against a cross-head and transmits the pressure through a spring S to the buffer P. The buffers P are thus pressed together at three points on their length. The cylinders F, E, D, D, are all connected to the same system of piping...

is limited, since the springs must be compressed and the cars coupled by impact. In the English system of coupling the cars are drawn together and pressure put on the buffers after the cars are coupled by a screw operated by hand. This method, however, is slow and crude, and involves the necessity of a man going between the cars. It is, moreover, inapplicable to automatic couplers.

In the hydrostatic system the pressure is let out from the cylinders when the cars are to be coupled, and a coupling may be thus effected with a slight impact. After the coupling is effected the pressure is pumped into the cylinders by an attendant in the car, and any desired amount of pressure may be put on the buffers. The pressure in the adjacent ends of two cars is pumped up to about the same amount (sufficient to put the springs under a heavy compression), as shown by the gauges.

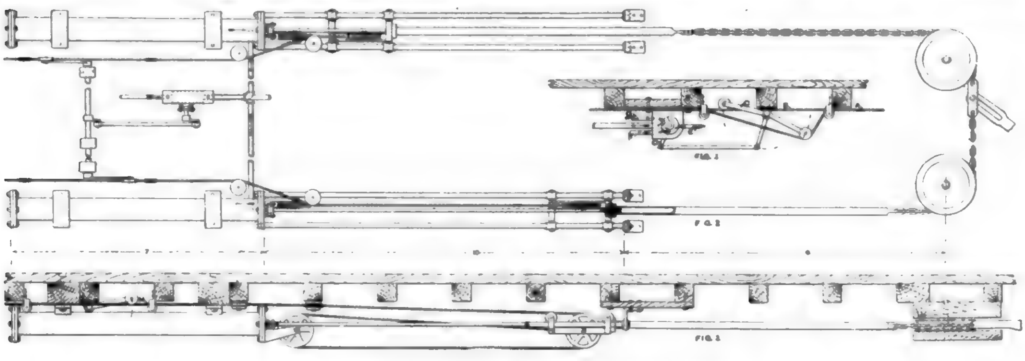
If one buffer has more pressure in the cylinders than the other, the buffer will move toward the car on which there is the smaller pressure. The leakage is very small, and may be supplied by a few strokes of the pump when required. The long buffer plates shown increase the area of friction surface between the buffers, and this, combined with the greater pressure between them, has a marked effect in reducing the oscilla-

tion of the cars. It also tends to hold the end of the car up on uneven tracks. In case of a low joint or depression in the track the truck will drop, and with the ordinary buffer the body of the car will follow the truck, and as the truck rises again the body of the car meets it and produces a shock. With the hydrostatic buffer, however, the friction between the plates is sufficient to hold the end of the car up for the moment as the trucks fall, and a much steadier motion is the result.

In rounding curves, as the cylinders on the end of one car are all connected, one end of the buffer is free to move in while the other moves out, the fluid passing from one side cylinder through the pipe into the other as the rams move, and thus serving the purpose of an equalizing bar to maintain a uniform pressure on each end of the buffer.

In case of a collision the hydrostatic buffer would afford much more protection to the cars and passengers than the ordinary system, both on account of the greater area of buffer, and also because the shock will be better absorbed by the hydrostatic buffer, since the force necessary to compress it is much greater.

In connection with this buffer the platform is extended out nearly to the width of the car body; this gives a wider space for the vestibule, if one is used, and increases the strength of the platform by affording an opportunity to put in additional timbers between the end sill of the car and the platform end timber. By increasing the width of the platform it becomes necessary to use hinged steps, which can be turned up out of the way when the train is running. The step *L* is pivoted, as shown, and is raised and lowered by the lever *M* and link *N*. When in a station the step is lowered for passengers. When running it is raised in the position shown on the left-hand side of the cross-section, and held in that position by a spring latch.



CRAWLEY & JOHNSTON'S STEAM STEERING GEAR.

STEAM STEERING GEAR.

MESSRS. CRAWLEY & JOHNSTON, of Cincinnati, O., have recently put a new steam steering gear upon the market, which is remarkably simple and effective. The general arrangement and proportions of the machine are very clearly shown in our engraving. The principle upon which the machine acts is, that, as the tiller rope is tightened, it opens a valve of a steam cylinder, admitting steam to one end of the same and drawing in the piston-rod, which is attached direct to the tiller of the rudder. As this piston comes in it slackens off on the tiller rope, and thus allows the valve to close and shut the steam valve. As long as the steering wheel is kept revolving, holding the tiller rope taut, the piston will travel forward and move the tiller until it is hard over on one side; but the moment the steering wheel is stopped and the tiller rope allowed to slacken, the piston stops its motion and the tiller is held in the position in which it happens to be at that moment.

Referring to the engraving, fig. 1 shows the arrangement of the tiller ropes as connected with the valve, and also a cross-section of the valve itself. This latter is a rocking valve of the D pattern. The line of rope at the point *A* represents both ropes, one being behind the other. As the line at *B* is tightened, the arm *C* of the bell crank lever is raised, and the lever *D* of the valve moved forward into the position shown. At this point it will be seen that the valve is thrown clear over on one side, and steam enters through the steam pipe *E*, and passes out through the pipe *F* to one of the cylinders. On the other hand, the exhaust of the valve allows the steam to escape from the pipe *G* of the other cylinder and out through the exhaust; thus as long as the valve is held in this position, the piston, which works in the cylinder into which the pipe *F* leads, will continue to travel until it has hauled the tiller hard over, where it is held by a stop.

The arrangement for automatically stopping and adjusting the position of the tiller is shown at the bottom of the engraving in fig. 3. The piston travel is 6 ft., and, as shown, the piston is clear out and the tiller is represented as hard over on the one side. As the tiller rope at *H* is tightened, the valve is moved over, as already described, and steam would be admitted to the front end of the cylinder *I* and the piston drawn in. As it does so the cross-head or traveler, *K*, is drawn back, and this is directly attached to the tiller chains, so that the tiller is thus moved. As it travels back it will readily be seen that the rope *H* is slackened off, and as a consequence of this the valve will be moved to its central position, locking the steam, unless the wheel in the pilot-house is kept turning, holding the tiller rope *H* taut. As the movement of the traveler slacks off three times as much rope at *H* as the distance which it travels, and as the piston travel from the central position to hard over is 3 ft., it will be seen that the wheel in the wheel-house must take up 9 ft. of rope in order to bring the tiller hard over to one side or the other from the central position. This, of course, makes a very delicate arrangement, and the adjustment of the tiller to any desired position may be made with the utmost sensitiveness.

The plan of using cylinders of long stroke for accomplishing work of a similar character is one with which all manufacturers of machinery in the West are more or less familiar. The same long stroke has been used very extensively throughout the saw-mills of the Northwest, in the steam-feed for moving their circular saw carriages, and one concern having heavy excavators have used long cylinders for swinging the crane for a number of years.

The gear shown in the engraving is taken from drawings of one used on the steamer *John Barrett*, where it is giving perfect satisfaction.

EXPERIMENTS WITH STAYLESS BOILERS AND STEEL FIRE-BOXES.*

BY AUGUST VON BORRIES.

I.—STEEL FIRE-BOXES.

Construction of the Boiler.—In consequence of the successful experiments which have been made on North American railways in the application of thin sheets of steel for fire-box purposes, the Royal State Railways of Hanover had a number of boilers made with steel fire-boxes in the years 1891 and 1892, the first of which has now been in service for 12 months. There was also a single steel fire-box put in the old boiler of the shops.

The construction of the new boiler is very similar to the typical American boiler with crown sheet supported by radial stays. These crown stays were chosen in order to avoid the bending of the crown sheet, which usually occurs with the

* Paper read before the Verein Deutscher Machinen-Ingenieure.

ordinary methods of strengthening with vertical and horizontal stay-bolts, and also to simplify the construction as much as possible. The crowns and side sheets of the outer shell of the fire-box can, therefore, also be constructed of thin sheets.

The fire door openings which have been used for the last year are constructed without a ring on the well-known Webb construction. The shell of the boilers has outer and narrow inner welts for the horizontal seams, riveted with four rows of rivets. The circumferential seams of the center course of the boiler run under the outer welt, while the inner welt stops with the end and back plates. The outer welts of the first and third rings butt up against the ends of the sheet of the central course. For connecting the shell with the smoke-box, a ring extending over the two seams was first used; afterward this was cut out with a notch at each seam under the connecting ring of the smoke-box in order to get access to the seams. The notch was then filled up by a filler held with a screw. The thickness of the sheets of the fire-box was calculated for a steam pressure of 180 lbs. to the square inch, under which the boiler works, and were as follows:

Tube sheet, .5 in.; back sheet, .39 in.; side and crown sheets, .35 in.; widest spacing of stay-bolts, 3.9 in.

A tube sheet was first experimented with which had a thickness of only .39 in.; the arch was first constructed on the American plan, supported by three water tubes, and so arranged that it did not come in contact with the sheets of the fire-box, in order to avoid any uneven heating of the latter.

Determination of the Properties of the Sheet.—In consequence of the very favorable experiments which were begun in 1886 leading to an extensive application of steel in the work shops, a number of boilers were constructed entirely of steel, as well as a number of others with copper fire-boxes. For the determination of the character of the steel the following specifications were laid down:

"The sheets of the shell, as well as the outer and inner fire-box walls, must be of first-class quality and of mild, open-hearth steel, with a tensile strength of from 48,000 lbs. to 58,000 lbs. per square inch, giving at least 25 per cent. elongation in a length of 7.9 in. The steel which is used in the smoke-box must have at least 20 per cent. elongation when subjected to the tensile test.

"In testing the sheets and rolled iron of both kinds of steel they must be cooled in water having a temperature of 83° F. from a cherry-red heat, and must show neither cracks nor flaws of any kind when afterward bent through an angle of 180°, the smallest diameter of the curve of which is to be equal to the thickness of the metal. Furthermore, the steel must be readily welded.

"The test pieces for tensile, bending, and hardening tests must be taken lengthwise, as well as crosswise of the rolling direction of the sheets.

"Test pieces: one piece must be cut from each boiler sheet in accordance with the judgment of the inspector. The same kind of steel may be used for angle and rolled braces, stay-bolts, rivets, screws, etc., as was used in the sheets of the shell."

In working, the sheets from different shops showed practically the same tensile strength and elongation, but different hardnesses. An especially hard tube sheet developed a tendency to crack. Those which were hardest, therefore, from a chemical standpoint, were sent back, and an examination of those which had cracked and several other plates gave a high percentage of phosphorus, so that afterward the highest limit of phosphorus for the firebox sheets was put at .04 per cent. in order to obtain a metal which showed no inclination toward detrimental cracks and flaws. As the boiler was already constructed this examination could be only partially complete; still further investigation showed that the phosphorus present was not more than .05 per cent.

It is to be remarked here that more particular attention should be paid to the chemical composition of sheets made in this country than in North America, because raw material here is less likely to be free from deleterious matter than it is in America.

Construction of the Boiler.—The following specifications are laid down for the working of steel plates: "The steel plates must be worked only when they are at a red heat or perfectly cold, and never in a half-heated condition. Flanged plates must be flanged with wooden hammers and afterward reheated and allowed to cool slowly. The outside sheets of the fire-box and those of the shell are to be bent cold. All sheets which are cut under the shears must be beveled off at an angle of from ¼ to ⅓ of their thickness. Sheets thus beveled and which cannot be worked by the machine tools must be cut with a flat or cape chisel and a light hammer, and afterward filed. It is not permitted to cut such bevels with heavy chisels and sledge-hammers.

"If it become necessary to reheat a steel sheet, the fire must be so arranged that there is a zone of from 6 in. to 8 in. in breadth between the heated portions and that portion of the plate which is left cold. This zone is for the purpose of doing away with unequal expansion and avoiding the deleterious influences which might result from heating. It is therefore forbidden to limit this zone by covering the sheet with damp lime or ashes.

"In assembling the sheets for riveting, it is desirable that they should be brought together, as far as possible, with screws. Where the use of the hammer is unavoidable, as light a hammer as possible must be used, and it must be employed with the utmost care."

The construction of the boiler offers no special difficulty, and with the exception of the flanges of the tube sheets is worked without any trouble.

Particular attention is paid to the calking, which is to be done on the outside of the seam with a blunt tool, and it has given no trouble whatever.

In this way these places have remained perfectly tight. The seam riveting is relatively made safer and tighter than with the ordinary lap seam, because the changes of form which occur with these latter, in the consequence of the expansion of the metal, does not occur. The metal in the sheet of the shell can also be made about 15 per cent. less in the new method of making seams than in the old.

The cost of building the boiler averages about 80 per cent. of that of the old form of boiler of equal dimensions with a copper fire-box, lap riveted seams, and correspondingly thicker sheets. The weight is also somewhat less than in the old construction.

Handling in Service.—The following recommendations are made for handling the steel fire-boxes in service: "Sudden and unequal heating and cooling of the fire-box walls is to be avoided; while heating and during the ordinary manipulation of the fire, the latter shall be kept as even as possible in order to avoid the admission of cold air at any one place. Large lumps of damp coal must not be thrown against the side sheets. It is forbidden to run with the fire door open. In shaking down and cleaning out the fire, the ash-pan dampers and the blower must be closed; the former must always be closed when raking down. Washing out with cold water is especially forbidden. It is recommended that as long a time as convenient shall be used for raising steam."

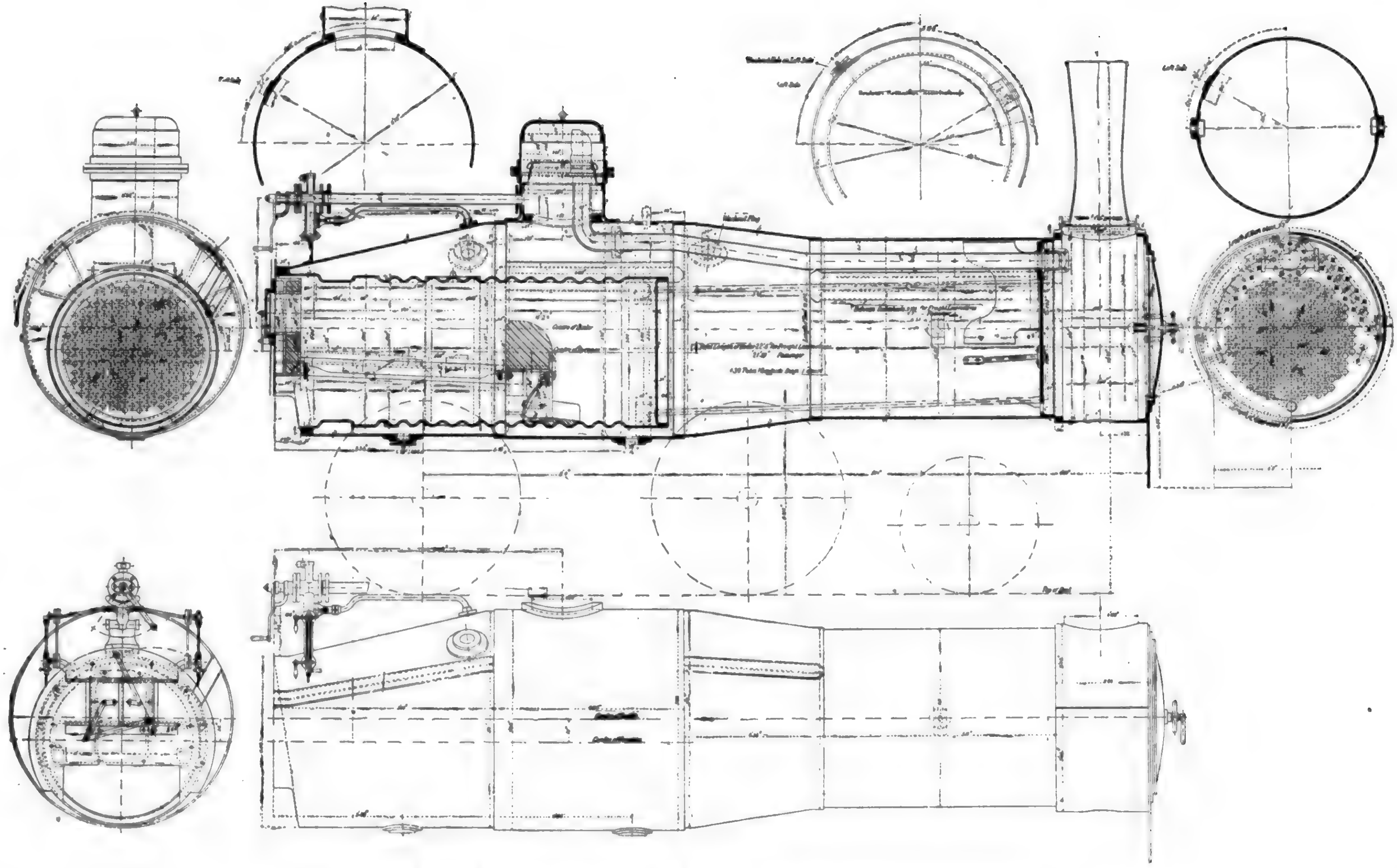
The Experiences in Service.—The performance of the boiler in service was at first but slightly satisfactory. The screwing in of the water tubes, which was done with brass ferrules with check-nuts, could not be kept tight. The check-nuts soon burned out. The escape water therefore caused the tubes, stay-bolts, and riveting to leak. Other screw ferrules with movable fastenings gave no better results, and, finally, the simple iron ferrule was the only thing found that would give lasting tightness to these locomotives.

After a short time a few of the tubes cracked in spite of the rapid circulation which obtained in the boiler on account of the deposition of scale, due to the highly impregnated water taken at the engine house at Hanover. In order to avoid the manifold troubles which were occurring with these water tubes, they were then removed from the locomotives and the brick arch was supported upon ledges attached to the side sheets in the ordinary manner. No evil results followed this movement, so that gradually all of the water tubes were removed. In spite of the heat of the sheet under, near, and above the brick arch, which frequently varies by many degrees, they withstood the expansion perfectly on account of the mildness of the metal, and gave no trouble whatever.

From that time on the principal cause of all the leakages with the water tubes was done away with, and the tubes, stay-bolts, and riveting kept tight very much better. The boilers built at different shops have developed very marked differences in this particular. Some are perfectly tight and fully equal to a copper fire-box; others are only moderately so. These latter have not been built with sufficient care. It is important to establish this point in order that these defects may not be attributed to the use of steel. The slightest defect in construction should be avoided with the utmost care.

It may be stated as the essential results of the investigations which have been made thus far, that no fire-box plate after the short service to which it has been subjected has sprung in the slightest, and that the steel taken from different works for locomotive fire-boxes has given essentially the same results.

What the life of these steel fire-boxes will be, and whether they will compare favorably with copper fire-boxes, time alone can tell. Therefore for the next year it is desirable that the boilers which have been built should be carefully compared in their performances with those having copper fire-boxes, in order to gather further experience as rapidly as possible.



STAYLESS BOILER DESIGNED BY AUGUST VON BORRIES, FOR THE HANOVER STATE RAILWAY.

It is more than probable, however, that the steel tube sheets will prove themselves superior to those of copper. They do not stretch so readily, and the tubes can be made far tighter. The copper tube sheets up to this time have shown many indications of a very short life, and lately several have been removed on account of the defects in the upper flanging and the tearing out of the upper stay-bolts, in consequence of considerable stretching, so that they had to be replaced after two or three years; and one is almost tempted to revert to the old method of the use of crown bars, which is still extensively used in England, or to consider some other method of staying which acts equally well.

On the other hand, the steel fire-boxes at the bottom of the side sheets and beneath the grates have developed a marked tendency to rust, which can only be explained by the deposition of moisture from the heated air on the cooling boiler. The cause of this rusting will be a further reason for avoiding, as far as possible, the putting of locomotives out of service, since the boiler can only be cooled off to any very great extent by washing out. This would be the reason that a similar rusting has not been observed in North America. The service of the sheets which are subjected to the direct action of the fire are still smooth and without any visible deterioration by rust.

A very slight amount of time that the locomotives are out of service acts as a special inducement for the further introduction of steel fire-boxes, thus forming a twofold means of cutting down expenses. In order to establish the final results on a sure basis, each fire-box must be removed which has shown any defect in its operation from the beginning, and to replace it by a steel fire-box of lasting tightness will be a work of no great difficulty.

THE STAYLESS BOILER.

Construction of Boiler.—In preparation for the investigation of economical boiler practice, a few stayless boilers were ordered by the Hanover Railway Company in the year 1886, built on the well-known Polmeyer system of construction, and afterward a larger number were designed differing in form principally in the shape of the shell, in order to obtain the best shape possible, and to cut down the weight of water contained to the lowest practicable amount. Consequently in 1890 the Leinhausen workshops built two stayless boilers, the general design of which is shown by the full-page engraving. The latest construction differs from them in its essential particulars only in that the lower part of the cylindrical shell is closed at the back by an arched sheet.

Furthermore, there are three points at which the cylindrical portion is not riveted to the longitudinal seams, but this was readily welded at the shops of Schulz, Knandt & Company, at Essen. Tests of the strength of these troublesome seams gave about 95 per cent. of the strength of the full sheet. The welding was preferred to riveting in order to keep the sheets as thin as possible.

As the boiler was still far too heavy, and put an excess of weight on the back axle of the three-coupled freight engine, to which it was applied in February and March, 1891, the form was still further modified and the back end made cone shaped, bringing it down to the Lenz form of shell. Instead of the welded longitudinal seams, riveting was again resorted to at a reasonable cost coupled with the use of the double welt.

Of this new construction of internal fire-box boilers four were put in service after a time; four more are being constructed, and 15 like the one illustrated are under contemplation. These differ from the two first built under the Polmeyer system and the first of the Lenz type in the following particulars:

1. The back tube sheet is not rigidly fastened to the shell, but the front end of the flue is attached to the shell by four brackets; the tube sheet can also, since the flue has some flexibility, follow the slight changes in the length.

2. There is no ashpit for the cinders other than that in the bottom of the flue, and the surface of the same, which is subjected to the action of the fire, is entirely free from rivet heads, seams, or other interruptions in the smoothness of the surface, since every such place gives occasion to an increase of wear.

3. The cinders are removed from the bottom of the flue through a trap-door lined with fire-brick, and by means of a special scraper.

4. In order to heat the cold water and draw it out from the bottom of the boiler there is a passageway made of sheet metal covering three of the corrugations of the flue, in which the water is heated to a higher temperature than in other portions, and consequently has an upward flow drawing its supply from the bottom of the boiler.

5. The back end of the flue is closed by means of a cast iron head, which is lined on the fire side with fire-brick and on the back side has an air space between it and the back head in order to prevent radiation as far as possible. The fire-brick is made entirely of one piece, as all ordinary constructions would not be able to withstand the great heat.

6. The water gauge has a special independent connection with the steam space of the boiler, so that its operation is not influenced in the slightest by the working of the injectors.

7. The tubes, which have an outside diameter of 1.8 in., are spaced 2.4 in. apart at the front end and 2.5 in. at the back, in order that the generation of steam, which is greatest at the back, may be freer, and there is more water space between the tubes for circulation.

These peculiarities were first embodied in the boilers built by the Hanover railways.

In other respects the flue is straight and horizontal, and the shell of the boiler is made of as few sheets as possible. The riveting of the horizontal seams is made with double welts and four rows of rivets. The longitudinal section of the boiler, which is given in our illustration, shows that the double grates are likewise made of one piece throughout their whole length, in order to facilitate the clearing out of the air spaces from beneath. The latter support of the grates on the flue is made with cast iron bars which lay in the corrugations of the flue and are held on the sides by being screwed to angle pieces.

Construction.—The sheets are made of open-hearth steel and the specifications for their manufacture and manipulation are the same, as has already been given for our ordinary boilers with steel fire-boxes. These flue boilers are being built to replace the old boilers that are wearing out. The expense of construction with grates and water gauges is 10 per cent. less than for boilers of the same capacity with copper fire-boxes and without grates and water gauges.

Handling in Service.—The only instructions which were given for handling these boilers in service were that the trap beneath the bridge wall and the back head of the flue should be carefully kept as tight as possible in order to avoid entrance of cold air into the ashpit. In cleaning out the cinder chamber before the trap is opened, the top of the stack must be closed with a sheet of metal so that the cold air may be prevented from passing through and striking against the hot tubes. On March 1 we had constructed and put in service these flue boilers as follows: One in February, 1891; one in March, 1891; two in December, 1892; one in January, 1893; one in February, 1893.

Four boilers are now already constructed and will be put in service in a short time. Fifteen are under contemplation and will probably be started during the year.

Results in Service.—After placing the two first locomotives in service, various troubles were developed which at first could only be observed upon the ground and after careful attention. Evaporation was insufficient because the exhaust pipe stood very high in consequence of the unsuitable form of the stack, producing an insufficient vacuum in the smoke-box. After these difficulties and other changes in the stack and blast-pipe had been effected, an analysis of the gases and a measurement of the temperature in the smoke-box was made. It was practically the same as in a locomotive, doing the same service with the ordinary fire-box and having a brick arch, and was as follows:

There was no difference in the combustion as far as thoroughness went, in the engines, and the amount of carbonic acid gas and the excess of oxygen was alike in both boilers.

The heat of the gas in the smoke-box averaged from 608° F. to 654° F. in the flue boiler, and from 518° F. to 572° F. in the ordinary boiler; thus the first was from 70° F. to 90° F. higher, which was evidently a result of its smaller heating surface. As for the difference in the heat of the gases at the top and bottom rows of tubes in the flue boiler, it was evident that the height of the blast pipe to the contracted portion of the stack had a great influence. At first the difference in the temperature was from 5° F. to 50° F. higher at the top than at the bottom; by raising the blast tube about 2.6 in. the difference was raised to from 68° F. to 108° F., and dropped when the blast-pipe was lowered below the first row of tubes to from 68° F. to 0° F. In the locomotive with the ordinary fire box the gases at the top row of tubes was from 18° F. to 35° F. hotter than at the lower. These results show that an average specimen of gas taken midway between the top and bottom row of tubes, with a suitable height of blast-pipe relatively to the stack, can also be obtained without making use of any special appliances, such as a brick arch over the bridge wall or deflection plate in the smoke-box.

Unequal drafts of the products of combustion through the

tubes also caused an uneven burning of the fire on the grates, a high position of the blast-pipe causing a rapid combustion at the front end of the grates and a weak combustion at the back, while, when the blast-pipe was low, the reverse was the case. These observations were also made on many other locomotives. The following table gives the results :

Position of the Blast Pipe Relatively to the Stack.	Draft of Gas through the Tubes.	Combustion in the Fire-box.
High.	Top.	Front.
Medium.	Even.	Even.
Low.	Bottom.	Back.

The proper position generally seems to be that in which the position of the blast-pipe relatively to the contracted portion of the stack is such that the top of the blast-pipe is three times the smallest diameter of the stack below it, and this is shown to be the proper place by a careful observation of the fire when testing the temperature of the smoke-box. This low position of the blast-pipe works just as well with the flue boiler as with the other in causing a rapid evaporation and ebullition of the water in the boiler. It is difficult to explain in what way this action is interdependent. It would be interesting and valuable to investigate as to what the results of experience have been in other places.

The leaking of the tubes in both of the original boilers was at first very considerable, because the traps beneath the bridge walls could not be kept tight and cold air would get through. These traps were for the purpose of protecting the high temperature in the bottom of the combustion chamber, where the cinders gathered, as much as possible, and these lay up against it so that it was frequently covered with red-hot ashes and was consequently warped and made loose by the heat. In order to avoid this, the traps in one of the locomotives was lined with fire-brick, whereupon the leaking ceased, showing that it was only necessary to get at the cause in order to stop the trouble with leaking ; then an order was given that the cinder space should be cleaned out at the end of every run by a workman crawling in over the grates, so that the locomotive should be as free from trouble in this respect as possible.

In boilers which were afterward constructed the trap was made larger and stronger, and so placed beneath the bridge wall that it was easily kept free of ashes. These traps have given very good results up to this time, and are not visibly warm even when the locomotive is working its hardest. Only upon the sides of the framing next the trap is there the slightest semblance of a dark red color. Both of the original boilers have also been lined with the best of fire-brick.

The back head of the fire-box must have the space between it and the corrugations of the flue well filled with fire clay made thick and thoroughly bedded in, in order that no cold air may enter through these spaces.

In the new boilers the tubes are fastened into the forward tube sheet on the American system with soldered copper ferrules .04 in. thick. In spite of this these boilers have several times given trouble with leaky tubes, which has, nevertheless, been attributed to the inadequate working of the blast in connection with bad feed-water and careless handling. By getting the blast-pipe into a proper location the tubes remained tight very much better, and will evidently have as long a life as those in the copper fire-box, since they can be fastened more securely in the steel sheets. When necessary the tubes can be screwed into the back sheets, as is frequently done in marine boilers, since their removal gives them a greater or less degree of inconvenience. Also a very fine thread could be cut in the hole in the sheet by means of which the ends of the tubes could be drawn back by turning them around. I hope that these difficulties will be overcome in a very short time.

The skill in firing on the inclined grates is very soon obtained by the fireman. Coal must be thrown into the fire-box more frequently than with the fire-box having a deep space over the grates, since the fire can only be maintained at a depth of from 10 in. to 12 in. For coal that burns with difficulty the heating surface must therefore be kept as large as possible, and care must be taken that coal is not thrown over the bridge wall. The fire-brick must also be built up again as soon as it is burned away to any degree.

The coal consumption, in spite of the smaller heating surface on these engines, the action of whose blast pipe was not altogether satisfactory, was not essentially greater than those with the ordinary fire-box, so that the evaporative efficiency of the flue boiler was considerably higher, and with an equal heating surface and the same steam pressure there should be no difference in the consumption of coal. The water may be kept at a high level in the boiler without any danger of particles being entrained into the cylinders. The time consumed in getting up steam in these boilers was about the same as with the others.

Cleaning out of the cinder space, which was made at the home station at the end of each run, is done by means of a scraper on a long handle made of gas-pipe. The trap is pushed open and held in position by a suitable strut with a long handle. The tubes are cleaned with a scraper at the end of a long handle. It is especially desirable that this work should be accomplished without there being any necessity for having a man crawl over the top of the grates, since the latter are very frequently hot, and the locomotive would have to be cooled off before the work could be done, which would necessitate its being out of service longer than desirable.

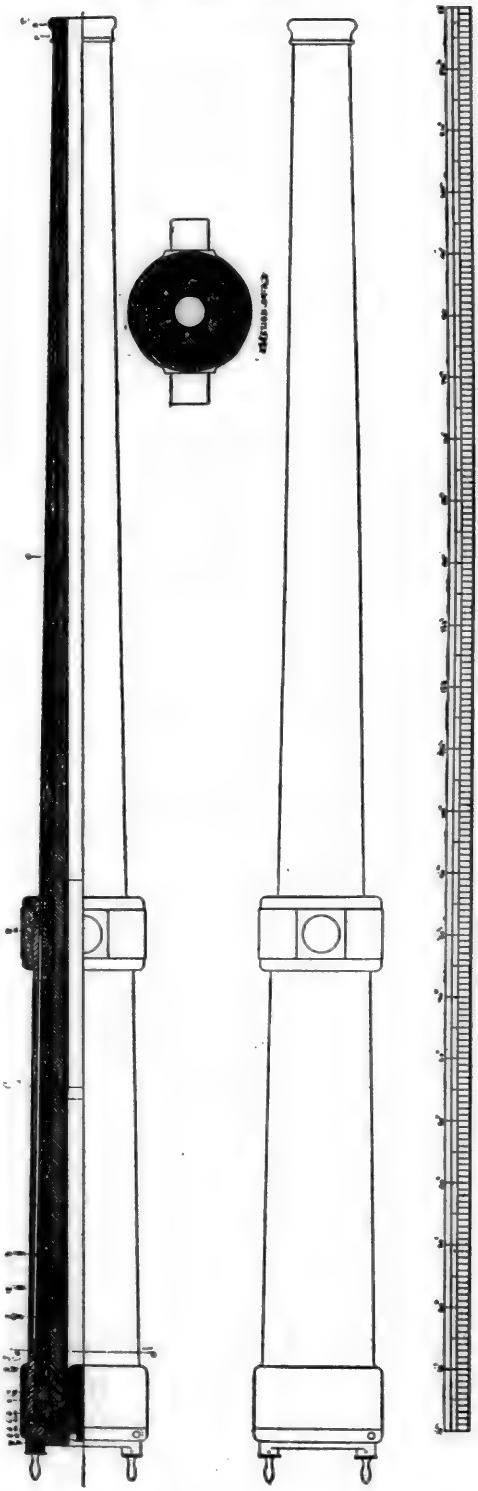
Maintenance of Boiler.—Beyond the repairs due to leaky tubes and the two transverse pieces on the lower portion of the cone-shaped ring, which were more or less leaky at the beginning, and the trouble with the burning out of the fire-brick, both of the original boilers having been in service for a space of two years, and do not as yet show any necessity for overhauling. The flues, as far as they can be inspected with lamps and reflectors through the hand-hole openings, seem to be perfectly uninjured on the lower side, although there is a slight coating of scale over them. On the inside beneath the grates there is a hard mass which consists of the salts of the ashes bedded into the corrugations, but it only contains a very slight amount of iron rust. There is very little iron rust to be detected on the inside. It would seem, therefore, that these flues are in a fair way to give a very considerable length of life ; but even if these further expectations are not fulfilled, and it should be necessary to renew them, it is a matter of no great difficulty, for the renewal of the flue would be very easy and would not occupy more than eight days at the outside.

The great expense which very frequently results from necessities for repairs on the ordinary fire-box, and the placing of the locomotive out of service in consequence thereof, will be avoided in the case of the flue boilers. The repairing of the other parts would be far simpler and easier, since we would not be so entirely dependent upon the capacities of our boiler shops. The accounts will show that there will be a saving of about 25 per cent. in repairs, or 5 per cent. of the total cost of the locomotive, and this can be reckoned as about 10 per cent. of the expense of repairs ; for a locomotive costing $10,000, which makes an annual run of 24,850 miles, and expense for repairs and renewals will amount to about $50 per 1,000 miles ; thus we have the following yearly account :

5 per cent. of $10,000	$50.00
Repairs, 24,850 miles at $50 per 1,000 miles	124.25
Total	$174.25

Therefore we have a corresponding saving in shop space. For a large road with 1,000 locomotives there would be a yearly saving of $174,250, a sum which is certainly worth looking after, and would seem to warrant especial attention toward the application of these flue boilers. If the results of experiments with flue boilers on other roads do not appear to be so satisfactory, the troubles which arise should be attributed to construction and handling. As in most other innovations, it is not sufficient that the boiler should be simply constructed and put into service in order that it may give good results. There are many things which will come up with any good thing which is new, whereby troubles will appear at first which can be easily overcome by careful attention. At first a watchful eye must be kept on all parts, for deficiencies will soon put in an appearance, and these must be met by careful personal attention. When the new device has been freed from its original defects and confidence has been obtained in the *personnel* of the men who have charge of it, it then remains for it to show whether it will meet expectations in the daily service, and whether these defects will grow.

I am thoroughly convinced that with careful handling the flue boiler is an innovation of the utmost importance. It readily lends itself to a rearrangement of the frames, so that in three-coupled freight engines a wheel-base of 13 ft. can be very readily obtained, which will permit of the speed of 25 miles per hour or more being maintained, and the frames can also be brought nearer together, so that room is secured for large cylinders, bogie trucks, and radial axles. The flue boiler is especially suitable for compound locomotives, since it can be used with a higher steam pressure, amounting to as much as 180 lbs. per square inch, with perfect safety.



SECTIONS AND SIDE ELEVATION OF THE BROWN WIRE-WOUND GUN.

THE BROWN WIRE-WOUND GUN.

THE Brown wire gun, says the *Journal of the United States Artillery*, consists essentially of a segmental core wound with wire, under such tension that the compression between the longitudinal segments of the core induced thereby will be more than sufficient to resist all ordinary powder pressure.

The longitudinal segments are primarily held together by a breech and muzzle nut, screwed on hot, with the proper degree of shrinkage, so that the tension of the nut and adjoining wire will be the same after winding.

The wire is wound between the nuts under a high degree of tension and anchored by a special device.

The trunnions are not attached to the core or body of the gun, but to an outer trunnion jacket, which jacket is attached to the gun proper by means of the breech nut. The breech block engages in a bushing which is screwed into the trunnion jacket. By this means the recoil is transmitted to the trunnions through the bushing and jacket; and the core or body of the gun is thus relieved from the major part of the longitudinal thrust due to powder pressure upon the bottom of the bore. The gun itself is free to expand longitudinally within this jacket, which is attached only to the breech nut.

The engraving shows a longitudinal section of the gun, and also a cross-section through the powder chamber, as well as the general contour.

The *modern system* of gun construction consists essentially of a core or body which is placed under a condition of "*initial compression*," by means of outer jackets of some kind; which are either shrunk on, as in the case of "*built up guns*" or wound on under tension, as in the case of "*wire guns*."

This "initial compression" produces in the core or body a circumferential compression, which is a maximum at the surface of the bore.

The action of the gunpowder is first to overcome the circumferential compression at the surface of the bore, and then to stretch the inner core or tube.

The action of the gunpowder is first to stretch the outer jacket, and compress the metal of the core, and after the initial compression has been overcome to stretch the core or inner tube, at the same time increasing the compression.

If the powder pressure is of such magnitude, that either the outer jacket, or core, is stretched beyond its elastic limit of extension, or the inner tube compressed beyond its elastic limit of compression at the surface of the bore, a permanent set will be given to the metal at some point; and on being released from the powder pressure, the gun *will not* return to its original condition and dimension. If neither of these limits are exceeded, the gun will return to its condition before firing, when relieved of pressure.

Many attempts have been made to use wire for the outer jacket of guns. In this connection, however, there is one serious difficulty to be overcome. A solid outer jacket has longitudinal strength; whereas a wire jacket of itself has none. Now the area of cross-section of the core or body of a properly constructed wire gun is about one-half of that of a solid "built up gun" of the same dimension; and about two-thirds of the thickness of the metal of a large "built up gun" can be utilized for longitudinal strength. The entire core of a wire gun, being in one piece, can be so utilized. Therefore, where the metal of the core or body of a wire gun has the same elastic strength as the metal of the "built up gun," the longitudinal strength of the wire gun is but three-fourths of that of the "built up gun."

Mr. Brown undertakes to solve the problem of longitudinal strength by increasing the elastic strength of the *core itself*. He *sub-divides the core or body* of his gun into *longitudinal segments* of such a size that a high condition of *special elasticity* may be set up therein and the requisite longitudinal strength be thus obtained.

By this process he can, without difficulty, *double* the elastic strength of the metal used in the core of his gun, still retaining sufficient ductility: and, therefore, although the area of cross-section of the core of his gun is but one-half of that of a solid "built up gun," the gun will have one and one-half times the longitudinal strength, as the metal has double the elastic strength of that used in the "built up gun."

But in order to do this does he not sacrifice the circumferential elastic limit for extension of his core? True, but as at the same time he can double the elastic limit for compression of the metal he can wind with twice the tension; and, therefore, double the initial compression at the surface of the bore.

In any gun the maximum safe value of the powder pressure must not exceed about 68 per cent. of the compression plus the elastic limit for extension, nor 94 per cent. of the elastic limit for compression. In order to determine the maximum safe powder pressure, we must determine which is the least of

these two values. The above figures are for a gun in which the minimum thickness of metal over the maximum powder pressure is one caliber.

For steel we may consider the two elastic limits as equal. In all guns the compression is made equal to the elastic limit.

In built up guns, therefore, the two values are 63 per cent. of twice the compression and 94 per cent. of the compression. Of course, the latter is the smaller, and therefore the maximum safe value of powder pressure.

In the Brown segmental wire gun the core has no elastic strength for circumferential extension; the two values are 63 per cent. of the compression and 94 per cent. of compression: the former is, of course, the smaller value. If, however, we can double the elastic limit, we can use double the compression, and therefore the maximum safe value of the powder pressure for Brown segmental wire gun will be to that of the built up gun as 126 is to 94.

We will now show that the claim that the segmental tube can be constructed of a steel having twice the elastic limit of that used in built up guns is entirely within the actual results obtained.

The physical conditions demanded by the Government for seacoast guns is shown by the following tables, taken from the report of the Chief of Ordnance of 1889, page 254, being a part of the specifications for steel forgings for 8, 10, and 12-in. guns, under Act of September 22, 1888.

These tables undoubtedly show the best conditions obtainable in large forgings from open-hearth steel. Table I. gives dimensions of specimens.

TABLE I.

"Each of the test specimens should show physical qualities given in the following table, No. I., which the manufacturer should aim to obtain."

CALIBER OF CANNON.	Designation of Pieces.	Elastic Limit. Lbs. per sq. in.	Tensile Strength. Lbs per sq. in.	Elongation after Rupture.
Seacoast, 8 in..........	Tube.	46,000	86,000	19 per cent.
	Jacket.	50,000	93,000	17 "
Seacoast, 10 in., and over................	Tube.	46,000	86,000	19 "
	Jacket.	48,000	90 000	17 "

TABLE II.

"The forgings shall, however, be accepted as to physical qualities, provided no one of the specimens shows results in any particular below the figures given in the following table, No. II."

CALIBER OF CANNON.	Designation of Pieces.	Elastic Limit. Lbs per sq in.	Tensile Strength. Lbs. per sq. in.	Elongation after Rupture.
Seacoast, 8 in..........	Tube.	42,000	78,000	17 per cent.
	Jacket.	46,000	85,000	16 "
Seacoast, 10 in. and over................	Tube.	42,000	78,000	17 "
	Jacket.	44,000	83,000	16 "

To distort the segmental tube of the 5-in. Brown gun would require a pressure of 94,000 lbs. per square inch, being beyond the possibilities of gunpowder. To distort the lining tube will require a pressure equal to 94 per cent. of its elastic limit. The probable elastic limit obtainable in lining tubes will be discussed farther on. However, as it is hardly probable that a breech mechanism will ever be devised, a carriage ever constructed, or a projectile ever be forged which will stand 60,000 lbs. pressure per square inch, it is waste of time to discuss these excessive theoretical pressures.

Longitudinal stress in a gun may be divided into two parts: that which is due to the pressure upon the bottom of the bore, and that which is due to the radial compression of the inner tube between the powder gas and the outer jacket.

In the Brown system the former is transmitted to the trunnion jacket through the breech nut, the trunnions being in no way attached to the segmental tube (see engraving). The segmental tube being required to take up only that longitudinal thrust due to compression between the powder gas and wire jacket plus that due to friction of the shot in the bore. Furthermore, as the trunnion jacket does not touch the segmental tube nor even the wire, and as there is a slip joint between it and the chase jacket, none of the thrust taken up by the jacket is transmitted to the segmental tube by friction. It must be remembered that as the liner in the Brown gun is in two or more pieces, and is not attached in any manner to the breech mechanism, it can do but little toward resisting longitudinal thrust. In calculating longitudinal strength the value of the liner has been practically ignored.

Mr. Brown, like Dr. Woodbridge, uses an inner solid liner, but he first winds his segmental core, and after the winding is complete he bores it out on a taper and inserts the liner by hydraulic pressure, thus insuring a true fit and uniform compression. The proposed method will probably be interesting. The gun, having been wound, will be bored to caliber, and the breech action fitted. The gun will then be *fired* in its unlined condition several shots. The firing will jar the segments into position, and even up the tension throughout the entire system. The gun will then be bored on a taper, and the liners inserted by hydraulic pressure. The lined gun will then be bored to a diameter slightly less than the caliber, and in this smooth bore condition will be fired up to and beyond the *maximum pressure* which the system is expected to stand during action. Heavy projectiles will be used so as to obtain high pressures. This will not only set the liner in position, but will determine its elastic condition for compression; therefore it cannot thereafter take a permanent set under a less compression. The gun will then be bored to caliber and rifled. It is manifest that by this process a condition of compression and fit between the various elements will be obtained, as perfect as it is possible to produce by mechanical operations.

It should be remembered that as the compression between the segments will not be reduced to zero during action, and as the segmental tube acts precisely as a solid tube until this compression is reduced to zero, the Brown segmental wire gun can be used without a liner. This was clearly demonstrated by the two cylinder tests, in their unlined condition. In neither case was there any radial or longitudinal displacement of the segments, nor was there any increase in the diameter of the powder chamber under high pressure. The only question which can arise, is whether there will be any tendency for scoring to follow the line of the joints between the segments. This can only be determined by actual test.

The theoretical circumferential strength of the 5-in. experimental gun is 100,000 lbs. per square inch.

It was desired to make this compression at the surface constant; but it can be shown mathematically that a constant rate of compression from breech to muzzle is not possible with a straight tapered core and a straight tapered exterior of wire jacket. The constant compression was thererefore sacrificed to ease of mechanical construction.

It will be noted, however, that the variation is comparatively slight. Being a maximum at the breech of 100,000 lbs. per square inch, and a minimum 50 in. from the muzzle of 96,000 lbs. per square inch, the minimum compression at the surface of the bore affected by the maximum powder pressure is about 99,800 lbs. per square inch.

Calculations made for a uniform tension clearly show that the wire has ample strength, and that the simpler method may be used with entire safety.

The trunnion jacket for the 5-in. B. L. rifle was made by the Bethlehem Iron Company. Tensile strength, 92,409 lbs. per square inch; elastic limit for extension, 49,916 lbs. per square inch; elongation after rupture in 2-in. specimen, 24 per cent.; minimum area of cross-section is 55.26 sq. in. The jacket will therefore stand, without taking a permanent set, a thrust of 2,758,238 lbs., and without rupture 5,160,337 lbs. The area of the breech-block is 21.65 sq. in. A powder pressure of 53,000 lbs. per square inch will give a longitudinal thrust of $53,000 \times 21.65 = 1,169,100$ lbs. There is therefore an ample margin of safety, with a factor of safety for rupture of 4.4.

It was originally intended to use an *increasing twist* curve, a semi-cubical parabola. The late experiments in England seem so clearly to demonstrate the advantage of the *uniform twist*, that the original idea has been abandoned. A polygroove system will be used: *uniform twist*, 24 grooves and lands; twist, one turn in 25 calibers; depth of groove, 0.05 in.; shape of groove similar to that of U. S. Army 10 in. rifle.

The liner is not an essential feature of this system of gun construction, but is introduced for the purpose of increasing the life of the gun. The *bete noir* of modern gun constructors is scoring; and the insertion of a thin lining tube furnishes a simple method of renewing the surface of the bore of a gun, by removing a scored liner and inserting a new one; thus materially increasing the life of the gun.

In connection with the segmental system a question has arisen in which there is a difference of opinion. That is whether a segmental gun should be lined throughout its entire length or only partially. It is contended that inasmuch as scoring in modern guns does not extend more than three or four calibers in advance of the seat of the shot, that a liner extending from the bottom of the bore to about five calibers in

advance of the powder chamber will be sufficient. On the other hand, it is contended that a segmental tube is more likely to score than a solid tube, there being a tendency to follow the lines of juncture; and therefore that it would be wise to line from breech to muzzle. It is further contended that the tendency to score will be increased by rifling the segmental core.

The 1-in. model gun was unlined and rifled, was fired under very high pressures, and no scoring was noticed, save at the *seat of the shot*. The gun, however, was not fired a great number of times.

Cylinder No. 2 when fired in its unlined condition showed a tendency to score along the lines of juncture after a pressures of 43,000 lbs. per square inch was reached. The reply to this fact is, that the unlined portion of the gun would never be subjected to such pressures. The problem can only be solved by actual test. At the present writing it is Mr. Brown's intention to line partially and to test the gun under high pressures; if scoring begins in the unlined bore, then to line from breech to muzzle.

sion of the liner; if, however, a liner can be constructed of crucible chrome steel having an elastic strength of 100,000 lbs. per square inch, the stresses in the liner will not pass through zero during the maximum action.

CONCLUSION.

The advantages claimed for the system are as follows:

First. By the longitudinal subdivision of the core, crucible steel can be used economically. Chrome steel can be used. A more perfect tempering is possible than in large solid tubes. A more careful and accurate inspection is possible. Small blow-holes will be reduced in diameter by the forging and rolling process, and can affect only the strength of a single segment. A higher condition of special elasticity can be set up in the metal than is possible in large masses. The maximum longitudinal strength obtainable from steel can be ensured by this process of construction.

Second. A higher initial compression can be given to the core or body of the gun, admitting of the use of higher powder pressure than is possible in the built-up system.

THE BROWN WIRE-WOUND GUN AS MOUNTED AT SANDY HOOK.

While it is impracticable to obtain large cylinders of much over 50,000 lbs. per square inch elastic limit, it is entirely practicable to obtain thin liners not over 1 in. thick, with very much higher elastic conditions.

The Bethlehem Iron Company have agreed to furnish a liner for the 5-in. experimental gun, with the following conditions:

Tensile strength, 105,000 lbs. per square inch.
Elastic limit, 60,000 lbs. per square inch.
Elongation in 2-in. specimens 15 per cent.

Such a liner inserted with a maximum tension will readily sustain a pressure of more than 50,000 lbs. per square inch without being overstrained.

If the liner be divided into two parts, the breech liner could be made of crucible chrome steel, and the chase liner of open-hearth steel, which would give ample elastic strength for the entire length of liner.

If a liner of 60,000 lbs. per square inch is used, it will, of course, be necessary to utilize the elastic strength for exten-

Third. In the Brown system the maximum strength of each portion of the gun is in the direction of the maximum stress it is called upon to bear. Neither in the core nor wire jacket does the condition of stress ever pass through zero during maximum action.

Fourth. A segmental gun can be constructed more economically than any other gun of equal power. The expense of casting, forging, and rolling the segments is much less than for large solid tubes. There is practically no risk of loss, as should a segment fail after treatment to show the necessary elastic strength, it can readily be rolled into commercial steel. The amount of machining is not greater than in a built up. The expense of winding is very small as compared with that of shrinking on jackets.

Fifth. The form, method of construction, and high power of the Brown segmental wire gun insures a greater muzzle energy per ton of weight than it is possible to obtain by any other system of gun construction now known.

Sixth. In the case of a sudden emergency the Brown guns

can be constructed in any machine shop having a lathe of sufficient length to receive the gun.

In order to give our readers an idea of what has been actually accomplished in the firing of the Brown gun at Sandy Hook, we append a record of the firings that were made by the officials of the Government with the apparatus installed at that point.

REPORT OF FIRING WITH 5 IN. B. S. W. RIFLE NO. 1, AT. U. S. PROVING STATION AT SANDY HOOK, ON AUGUST 18, 1893.

No. of Fire.	Powder.		Projectile.		Instrumental Velocity at 250 ft. from the Muzzle, ft. sec.	Pressure in Bore, Lbs. per sq. in.	Remarks.
	Kind.	Weight. Lbs.	Kind.	Weight. Lbs.			
86	Leonard Smokeless Ruby, N. C., Long Grain. Du Pont's Brown Prismatic.	7	Steel.	62	1,694	[illegible]	Short grains.
88		7.25			1,690	19,100	
[illegible]		9			1,841	under 24,000	
91		11			1,965	[illegible]	
[illegible]		13			2,197	28,700	
95		15			[illegible]	[illegible]	
96		17			[illegible]	[illegible]	
[illegible]		19			2,770	46,550	Mixed grains.
98		[illegible]			2,768	[illegible]	
[illegible]		21			2,839	[illegible]	est record in the world.
87		25			1,712	Lost.	
[illegible]		25			[illegible]	Under [illegible]	
92		30			1,870	[illegible]	
94		35			2,021	[illegible]	

ARBEL'S WHEELS.

Among the many interesting exhibits at the Columbian World's Fair in Chicago, the one of which we give an engraving herewith, of wrought iron car and locomotive wheels, made by the Anonymous Manufacturing Society of the Arbel Establishments, from Rive de Gier, France, is well worthy of the study of American railroad men. This company has issued a descriptive pamphlet of their exhibit, which contains an historical account of the evolution of wrought-iron railroad wheels, of which we have made very free use in the preparation of the following account of the methods of manufacturing such wheels which have heretofore been used, and of those which are now employed in the Arbel establishments.

In the early days of railroading, car and locomotive wheels were made in Europe of a combination of wrought and cast-iron parts. The spokes and the rims of the wheels were made of wrought iron and the hubs of cast iron. The process of manufacture may be described as follows: The spokes were made of wrought iron bent into the form shown by figs. 1 and 4. They were then assembled in a mold in the relation to each other which they were intended to occupy in the wheel, as shown in figs. 2 and 5. Melted cast iron was then poured into a suitable cavity at the center, which thus formed the hub. This hub when it was cast surrounded the ends of the spokes in a length of from 3 to 5 in., and held them in their position. The spokes were formed of various shapes, and parts of the bars from which the spokes were made formed the elements of the rims, as will be apparent from figs. 1, 2, 4 and 5. The spokes were either riveted together, as shown in fig. 5, or in wheels like that shown in fig. 2; triangular pieces were fitted in where the elements of the rims joined each other, as indicated by the shaded areas in fig. 12, and they were then heated and welded at these points.

Fig. 1.

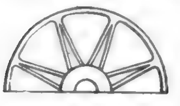


Fig. 2.

These wheels had very little strength, as the spokes and the rivets often worked loose. The exclusive use of wrought iron was a consequence of these defects, and of the use of heavier cars and locomotives and greater speed.

Fig. 3.

Before steam hammers were as generally used as they are now wrought-iron wheels were made by the following processes: 1. The spokes were first prepared by binding a piece of iron, as has been described. Sometimes these elements were made to form part of the hub as well as of the rim, as will be explained. 2. The hub was prepared to weld to the spokes. 3. The spokes and hub were welded together. 4. The parts of the rim were welded together.

To make these processes clear, it may be said that one form of wheel is made as follows: Pieces of iron of the form shown by figs. 7 and 8 were made in special rolls designed for the purpose. These were then bent into the form shown in fig. 9 in a special screw press. The elements which form the spokes, rim, and part of the hub are then assembled together and held by a suitable clamp, as shown in fig. 10. Distance pieces, shown by the shaded areas near the center of fig. 10, are then driven in between the ends of the spokes which form part of the hub. The assembled parts are then placed on a small circular forge, so that the central part, for a short distance outside the keys, is heated to a white welding heat. At the same time a hub, which has been made of the form shown in section by the shaded area in the middle of fig. 11, is also heated in a furnace to the same temperature as the hub in a suitable furnace. When they have both reached a welding heat the hub is placed in a special die under a steam hammer, while the workmen with a crane quickly bring the whole of the assembled spokes on the hub which projects above the opening, as shown in fig. 11. The hammer-head is also provided with a suitable die which with a few blows quickly compresses the hub and brings it to the form indicated by the dotted lines. The hub and the ends of the spokes are thus thoroughly welded, and at the same time a hole is started in the top of the hub. The diaphragm of solid metal, which is left between the upper and lower holes, is removed by driving a punch through it under the hammer. The wheel is then of the form shown in figs. 12 and 13. Wedge-shaped pieces, shown by the shaded areas in fig. 12, are then inserted in the spaces when the bent "forms" join each other at the rim. Each one of these junction points is then separately heated and welded. These processes are still extensively employed in England and Germany.

Fig. 4.

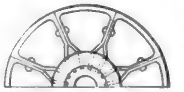


Fig. 5.

Fig. 6.

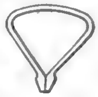


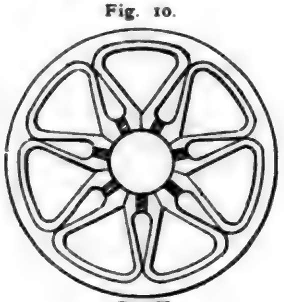
Fig. 9.

Fig. 7.

Fig. 8.

Figs. 14, 15, 16 and 17 show a similar method of making a wheel of somewhat different form. The method of manufacture will be apparent from the engravings without further description. In the form of wheel shown in fig. 15, the wedge-shaped pieces are inserted from the top and bottom instead of from the outside of the periphery of the rim at the points where the rim is welded together.

Fig. 10.



Still another method is shown in figs. 18–22. A hub shown in fig. 18 is first forged with short projections, which are intended for rudimentary spokes. T-shaped pieces, shown in figs. 19 and 20, are then made, the vertical part of which forms the spoke and the horizontal portion the rim. These are then assembled and held in a suitable clamp, as shown in fig. 21, and a separate heat and separate weld is made for each junction of the spokes and rim. The whole of this work may be done by hand and without the aid of a steam hammer.

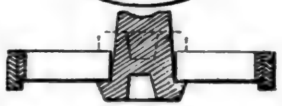


Fig. 11.

ONE-PIECE WROUGHT-IRON WHEELS.

At the Arbel Works wheels are made by stamping under a hammer a wheel which has been thoroughly heated, all the

parts of which have previously been fitted together cold. The process of manufacture for car-wheels is as follows:

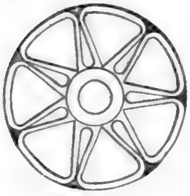


Fig. 12.

Fig. 13.

A bar of suitable section is bent in rolls to form the rim. This ring of metal is then held in a clamp provided with screws, as shown in figs. 23 and 24, the unwelded ends of the bar abutting together. It is then placed in a fire and the ends heated to a welding heat. By turning the screw the ends are then pressed together, and only a few blows are needed thereafter to make a perfect weld.

Grooves are then cut by a special machine in the inside of the rim to receive the ends of the spokes, as shown in fig. 25. assembled, as shown in figs. 25 and 26. An important feature in this making up is the "dish" which is given to the wheel, which must always be greater than that necessary for the finished wheel, and which gives sufficient stability to the assembled parts to enable them to be handled and insures a perfect welding of the spokes and rim by the compression which occurs in the direction of the spokes during the stamping of the wheel. In order to obtain a good forging, the width of the "shapes" of wrought iron are also made greater than that of the finished rim and spokes, so that in the process of stamping the metal is compressed and condensed.

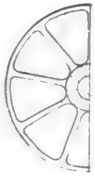


Fig. 16.

Fig. 17.

To weld the parts of the wheel together, it is taken up by a pair of tongs suspended from a traveling trolley, and is placed

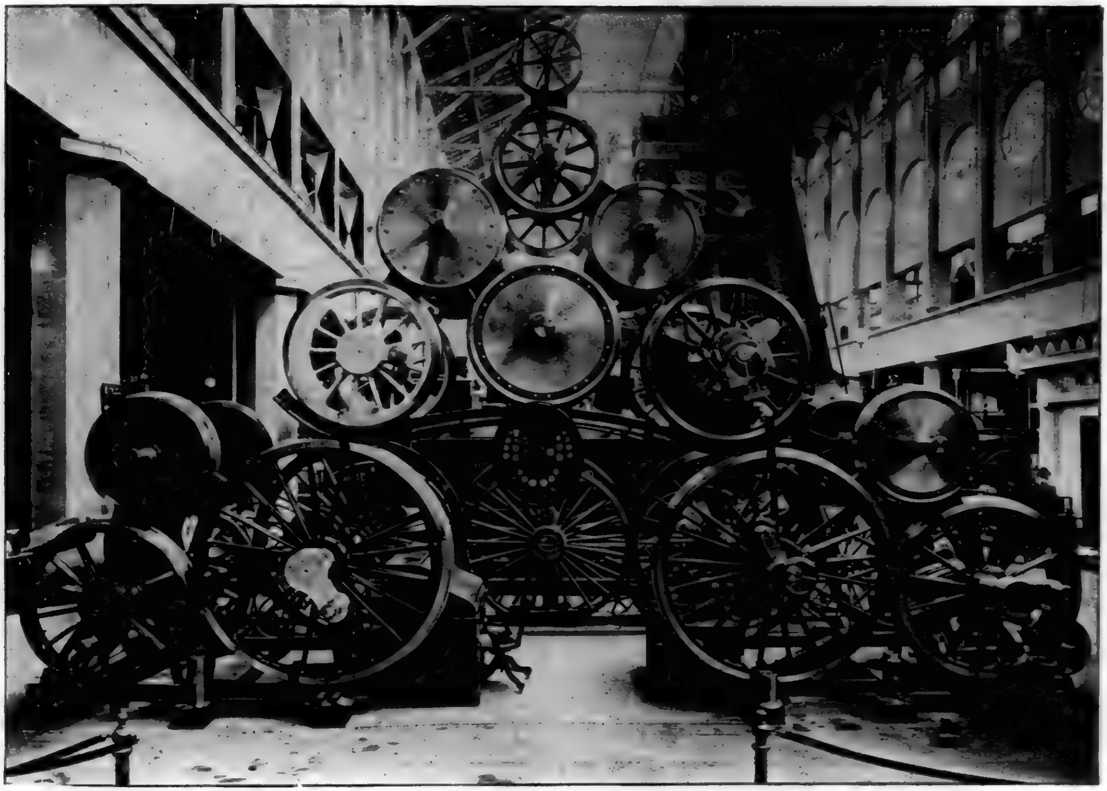


EXHIBIT AT CHICAGO OF THE ARBEL'S ESTABLISHMENTS, RIVE DE GIER, FRANCE.

The spokes are formed of bars which have been rolled to an elliptical shaped section, and are upset in dies at their outer and inner ends, where they are welded to the rim and hub.

Fig. 14.

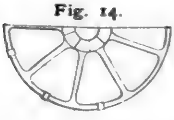


Fig. 15.

The hub is made in two halves, as shown in section in fig. 26, the upper and lower portions being separate. These are made from a rectangular rolled iron bar, which is heated to a white welding heat, and then bent under a steam hammer around a conic mandrel with special dies. It is then reheated and put between two dies, one fitted to the hammer and having suitable cutters, the other fitted to the anvil and having cavities corresponding to the cutters. By this means grooves are cut in the periphery of the hub to receive the spokes. The spokes, the rim, and the hub are then in a furnace. If it were heated in an ordinary furnace, the lighter parts would be destroyed before the heavier masses were thoroughly heated. To avoid this a special form of furnace, in which the heat is not transmitted by direct contact of the flames to the wheel, but by reverberation, has been devised. The maximum intensity of heat in this furnace is at the center of an arch—that is to say, on the hub, the heaviest part of the wheel. In this way the heat is transmitted to the wheel, so that all its parts are gradually and regularly heated and brought simultaneously to a welding heat.

Fig. 19.

Fig. 18.

Fig. 20.

When the wheel has been uniformly heated to a white welding temperature, it is taken again with the same pair of tongs

and put in a die attached to the anvil of a steam hammer. This die forms a mold for one-half of the wheel, and another die, fastened to the hammer, forms the other half. A few blows of the hammer are sufficient to give a perfect welding of all the parts of the wheel. A second and similar heating is given to finish it. When the wheel leaves the hammer the dies leave fins on the wheel where they join each other. These must be cleaned off, and it is then turned and bored. It then passes to slotting, planing, finishing, milling machines and lathes, in which it is finished, and is then ready for delivery.

LOCOMOTIVE WHEELS.

The old method of making wrought-iron locomotive wheels is shown in figs. 27–30. The elements forming the spokes, rim, and part of the hub are made of the form and assembled, as shown in fig. 27. One large element, shown on the right side of fig. 27, is made to form the crank-pin hub and counterweight. The hub is made of a dished shape top and bottom, as shown in fig. 28.

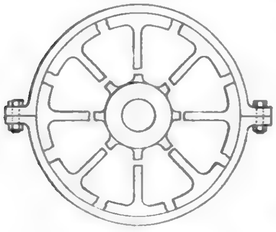


Fig. 21.

Fig. 22.

Washers are welded to the hub, in these dished receptacles, and complete it. Separate welds are made in the rim between each two spokes, as has been explained. The finished wheel is shown in figs. 29 and 30.

This method of manufacture does not require many tools, but is far from being economical, and requires a great number of welds, which, being made one after another, cause unequal contraction and expansion in the metal which subject the wheel to injurious strains.

To get over these difficulties, the Arbel Company have adopted the following process: The rims are made by the same process as is employed for car-wheels. The spokes are formed by upsetting their two ends and drawing them out under a hammer, so as to reduce their size toward the rim until their shape is like that shown in fig. 31. These parts are then assembled, as represented in the figure last referred to. A pile is then made of suitable size and shape to form the crank-pin and central hubs, and still others to form the counterweight, as shown in the section, fig. 32. The assembled wheel is then heated and stamped between suitable dies under a steam hammer, as has been explained. This process, it is claimed, is much more economical and gives products of incontestable superiority.

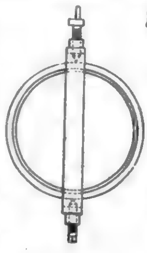


Fig. 23.

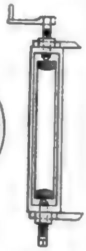


Fig. 24.

VARIOUS TYPES OF WHEELS MADE AT THE ARBEL WORKS.

Besides the spoke-wheels, the process of manufacture of which has been described, there are manufactured at the Arbel Works, and are exhibited in Chicago, wrought-iron plain disk wheels, wrought-iron corrugated disk wheels, wrought-iron plain disk wheel with ribs.

The finished spoke-wheel is shown by figs. 35 and 36. Its characteristics are spokes of elliptical section, with a rim which is thicker in the center and of a width nearly equal to that of the tire.

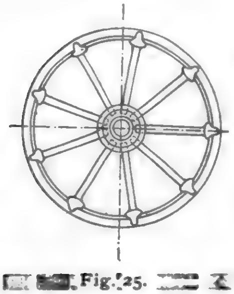


Fig. 25.

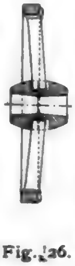


Fig. 26.

The plain wrought-iron disk wheel, shown by figs. 37 and 38, it is claimed, has the advantage of not raising as much dust as spoke-wheels do. It is said, however, that, owing to the unyielding form of this form of disk, the tires are liable to get loose, and that the disk has but little capacity to resist the end thrust of the axle.

The corrugated disk wheel, figs. 39 and 40, is said to be more elastic than the plain disk wheel, but has even less capacity of resistance to the end thrust of the axle.

Owing to these objections to the two forms of disk wheels, the Arbel Company have brought out a disk ribbed wheel. shown in figs. 41 and 42. This form of wheels was thoroughly tested by M. L. Durant, the assistant of Mr. Ernest Polonceau, Chief Engineer of Machinery and Traction of the Orleans Railway Company of France. A full report of this test is published in the descriptive pamphlet of their exhibit which the Arbel Company have issued. For this report we unfortunately have not room. Mr. Durant, however, concludes that "the ribbed wheels of the Arbel system have marked advantages over other kinds of wheels. It solves to a great extent the problem of suppressing dust during the train's passage; it offers a great resistance to the setting up of the center of the axle, to the shoeing and to the different strains which it must bear when in use, and its qualities of resistance indicated by the calculation have been confirmed by very recent experiments."

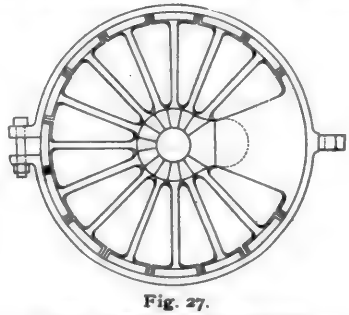


Fig. 27.

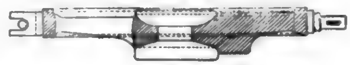


Fig. 28.

Fig. 29.

Fig. 30.

The merits of wrought-iron wheels, it is thought, have never been fully recognized in this country. In view of this, the exhibit of the Arbel Company is worthy of careful examination by our railroad managers.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

THE object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in August, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN AUGUST.

Hagerstown, Md., August 1.—A freight car on the Baltimore & Ohio Railroad, which was being loaded with wheat on the switch of the Frederick Elevator Company, got beyond

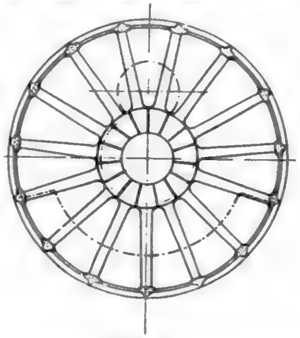


Fig. 31.

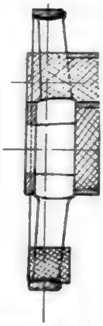


Fig. 32.

the control of the brakeman this afternoon, and running down the track came into collision with the locomotive and several passenger cars. The pilot was damaged and the end of one passenger car badly broken. William Hauer, a fireman, was caught on the platform and received severe but not dangerous injuries.

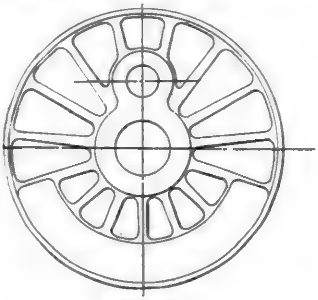


Fig. 33.

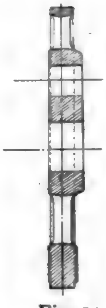


Fig. 34

Worcester, Mass., August 2.—E. H. Ford, a fireman on the Boston & Albany Railroad, was struck by a train in the freight yard last night and seriously cut on the head.

Streator, Ill., August 2.—A stock train consisting of 26 cars, on the Atchison, Topeka & Santa Fé Railroad, ran on to a side track to-night at Kinsman, 18 miles north of this city.

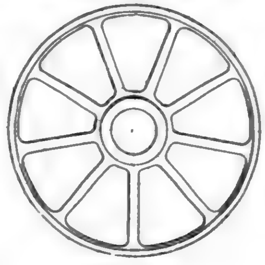


Fig. 35.

Fig. 36.

The engine was thrown from the track by striking some cars loaded with lumber and flour. Fireman J. Leary jumped and received severe injuries about the legs. Eighteen cars were wrecked and about 30 head of cattle killed. The wreck took fire, and the cars, dead stock, elevator, and depot were entirely consumed.

Macungie, Pa., August 3.—Through a misplaced switch two freight engines were badly wrecked to-day. Engineer George Leeds was considerably injured.

Danville, Ill., August 5.—An east-bound freight train on the Big Four Road broke in two on the iron bridge over the North Fork River. Another east-bound freight train came round the sharp curve to the west of the bridge, and a collision occurred. Two spans of the bridge were knocked off the pier into the river, 63 ft. below. The engine and 28 cars composing the second train and four cars of the first train went

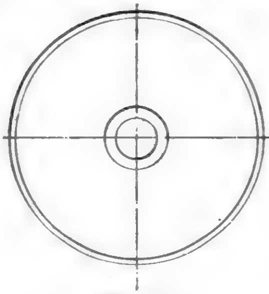


Fig. 37.

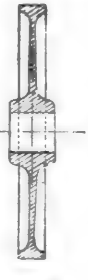


Fig. 38.

down with the bridge. Daniel O'Connor, engineer of the second train, jumped off his engine, landing on a barbed-wire fence and was severely scratched. His fireman, Frank Flannigan, went down with the engine. In some way he cleared the wreck and was not seriously hurt.

Fremont, O., August 5.—A wreck occurred 8 miles west of here at Lindsey, on the Lake Shore & Michigan Southern Railroad, this evening, at 10 o'clock. Three people were killed

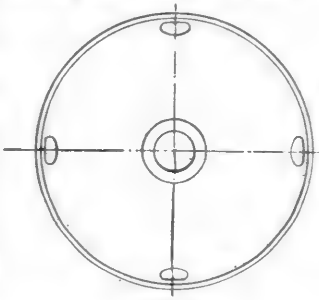


Fig. 39.

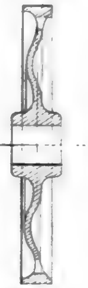


Fig. 40.

outright, and 25 were more or less injured. The Pacific express passed a local freight at Lindsey, which had been side-tracked. The express was running at full speed and passed safely until the sleepers neared the switch close to the freight, when the first three sleepers jumped the track and ran into the engine of the freight. Engineer Ed. Lafferty, of the freight train, was killed.

Laredo, Tex., August 7.—A wreck occurred on the Southern Division of the Mexican National Railroad near Colonia, Mexico, in which Engineer John Peterson lost his life. A cloud-burst had occurred in the valley on the line, washing away a bridge and considerable track. A freight train was on the line coming down at the time, and before it could be stopped the engine ran off the dump into the stream from which the bridge had been washed away.

Little Ferry, N. J., August 8.—The New York, Susquehanna & Western Railroad Company is building a bridge over the West Shore track near this point, and some timbers had been left standing near the rails. Engineer James Loane, of the New York, Ontario & Western milk train, was leaning out of the cab window as he passed this place to-day, and was struck on the head by one of the timbers, receiving a severe scalp wound.

Philadelphia, Pa., August 9.—William H. Frick, an engineer on the Wilmington & Northern Railroad, fell from his engine at Landenberg to-day, badly spraining his back.

Reading, Pa., August 9.—John Sainer, an engineer on the Philadelphia & Reading Railroad, while engaged in cleaning his engine last evening fell from his cab to the ground, severely spraining his right leg.

LOCOMOTIVE RETURNS FOR THE MONTH OF JUNE, 1893.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Locomotive Mileage. Freight Trains	Locomotive Mileage. Service and Switching.	Locomotive Mileage. Total	Locomotive Mileage. Average per Engine.	Av. Train. Passenger Cars.	Av. Train. Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Coal Burned per Mile. Freight Train Mile.	Coal Burned per Mile. Service and Switching Mile.	Coal Burned per Mile. Train Mile, all Service.	Coal Burned per Mile. Passenger Car Mile.	Coal Burned per Mile. Freight Car Mile.	Cost per Locomotive Mile. Repairs.	Cost per Locomotive Mile. Fuel.	Cost per Locomotive Mile. Oil, Tallow and Waste.	Cost per Locomotive Mile. Other Accounts.	Cost per Locomotive Mile. Engineers and Firemen.	Cost per Locomotive Mile. Wiping, etc.	Cost per Locomotive Mile. Total.	Cost per Car Mile. Passenger.	Cost per Car Mile. Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé	834	725	....	....	....	2,158,645	2,977	....	....	....	....	....	....	....	....	4.87	6.54	0.29	0.15	7.13	1.05	20.03	....	....	1.52
Canadian Pacific	612	....	526,283	755,528	484,707	1,766,518	2,886	....	....	....	....	....	62.69	....	....	3.89	9.86	0.33	....	5 62	1.34	21.04	....	....	3 13
Chic., Burlington & Quincy	542	....	....	....	....	1,678,784	3,097	5.60	18.58	....	....	....	81.78	....	..	4.59	5.49	0.22	0.17	6.88	0.06	17.41	....	....	1.34
Chic., Milwaukee & St. Paul	825	...	....	....	....	2,386,559	2,771	....	....	....	...	....	67.77	....	....	4.20	6.97	0.29	...	6.89	....	18.35	....	....	2.00
Chic., Rock Island & Pacific	564	....	609,564	906,005	402,012	1,917,581	3,399	....	..	57.34	76.21	39.20	62.44	...	....	2.99	5.69	0.27	2.90	6.04	0.43	15.42	..	...	1.96
Chicago & Northwestern	888	....	762,108	1,307,570	741,262	2,810,940	3,165	....	...	....	....	....	79.33	..	....	3.58	7.46	0.36	....	6.40	0.81	18.61	....	....	1.86
Cincinnati Southern	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	...	...	....	....	....	....	....
Cumberland & Penn.*	....	22	5,896	31,968	....	37,864	1,721	....	....	....	....	....	99.00	....	...	6.13	4.52	0.39	....	...	1.85	12.89	....	....	....
Delaware, Lackawanna & W. Main L.	211	193	71,075	669,541	5,100	745,716	3,834	....	....	....	....	....	81.80	....	....	3.17	6.45	0.46	....	5.84	....	15.92	....	....	1.60
Morris & Essex Division	160	..	177,118	165,471	93,887	436,476	2,728	....	....	....	....	....	62.99	....	....	4.28	9.76	0.40	....	6.36	....	20.80	....	....	3.08
Hannibal & St. Joseph	74	...	....	....	....	256,839	3,669	6.02	17.08	....	....	....	80.08	12.88	5.83	3.82	5.45	0.13	0.21	6.71	0.02	16.34	....	....	1.39
Kansas City, F. S. & Memphis	139	....	98,355	189,863	97,023	385,247	2,764	....	....	....	....	....	60.95	....	....	4.46	5.35	0.19	0.41	7.51	...	17.92	....	....	1 62
Kan. City, Mem. & Birm	42	37	35,320	46,914	17,765	99,999	2,702	....	....	....	....	...	....	....	....	3.79	3.09	0.23	0.34	7.19	....	14.64	....	....	0.98
Kan. City, St. Jo. & Council Bluffs	38	....	....	....	....	136,281	3,586	4.94	21.45	....	....	....	65.12	13.12	4.60	3.98	5.87	0.13	0.23	6.04	0.03	16.28	....	....	1.90
Lake Shore & Mich. Southern	586	....	528,976	765,566	488,081	1,821,563	3,108	....	....	57.42	85.08	37.46	60.87	....	....	3.06	4.74	0.18	....	6.85	0.19	15.02	....	...	1.55
Louisville & Nashville	....	....	....	....	....	....	...	....	....	....	..	....	....	....	....	..	....	....	....	...	....	....	...	....	....
Manhattan Elevated	....	303	741,576	....	60,807	802,383	2,648	....	....	...	....	....	40.78	....	....	3.20	3.30	0.20	....	9.00	....	20.70	....	....	4.05
Mexican Central	148	118	....	....	....	406,258	3,443	..	....	....	....	....	70.67	....	....	5.91	14.62	0.55	0.23	5.27	0.83	27.40	....	....	4.41
Mil., L. S. & Western	112	....	93,993	147,677	74,517	316,187	2,823	....	...	....	...	....	67.26	....	....	3.22	9.34	0.15	....	6.14	0.89	19.74	....	....	2.80
Minn., St. Paul & Sault Ste. Marie	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	...	....	....	...	....	....	....	....	....	....
Missouri Pacific	338	....	....	....	....	1,073 311	3,548	4.44	16.47	....	....	....	82.65	4.32	1.66	5.25	5.75	0.46	1.44	6.41	1.36	20.67	3.95	1.57	1.35
Mobile & Ohio	107	80	69,698	152,323	57,974	279,995	3,499	..	19.60	....	....	....	56.91	....	....	2 63	4.32	0.32	0.63	5.75	0.93	14.45	....	....	1.43
N. O. and Northeastern	....	....	....	....	....	....	....	....	....	....	....	....	...	....	....	....	...	....	....	....	....	....	....	....	...
N. Y., Lake Erie & Western	617	411	466,565	898,575	282,883	1,646,023	4,005	4.80	23.1	86.50	127.20	66.2	....	17.90	5.50	4.82	7.13	0.38	2.38	7.29	1.11	23.04	....	....	1.86
N. Y., Pennsylvania & Ohio	253	161	158,802	394,308	160,222	713,332	4,430	5.70	19.1	59.30	131.80	75.5	....	10.40	6.90	3.64	6.24	0.30	2.35	6.90	0.99	20.42	....	..	1.21
Norfolk & Western, Gen. East. Div.†	....	....	126,411	273,991	56,227	456,629	2,784	5.00	20.90	46.30	121.30	....	....	9.30	5.60	5.90	3 90	0.50	....	....	....	10.30	....	....	....
General Western Division†	....	....	115,908	284,177	49,634	449,719	2,498	5.40	16.70	66.00	119.00	....	....	12.32	7.66	7.17	4.26	0.42	....	....	....	11.87	...	....	....
Ohio and Mississippi	117	...	143,249	139,561	98,850	381,659	3,262	....	....	....	....	....	80.61	....	....	3.12	3.15	0.26	1.30	5.40	1.40	14.63	....	....	0.77
Old Colony	....	...	....	....	....	....	....	...	....	....	....	....	....	...	....	....	....	....	....	...	....	...	....	...	....
Philadelphia & Reading	....	....	478,079	316,150	1,013,508	1,807,737	....	....	....	....	....	....	74.79	....	..	4.80	4.61	0.36	....	5.77	0.42	15.96	....	....	....
Southern Pacific, Pacific System	720	666	691,971	....	....	1,820,639	2,734	5 58	13.86	....	....	....	67.34	....	....	5.08	17.57	0.91	1.46	7.27	1.11	33.40	....	..	5.27
Union Pacific	992	..	677,054	1,240,657	408,797	2,326,508	2,968	6.08	17.01	...	...	....	93.81	....	....	7.50	9.49	0.39	0.94	8.05	1.20	27.57	4.10	2.08	2.05
Wabash	426	364	434,999	682,304	273,284	1,390,587	3,820	5.02	16.80	60.62	98.52	52.11	79.46	13.26	5.66	3.58	4.35	0.30	....	6.22	0.89	15.34	2.44	1.00	1.12
Wisconsin Central	152	111	125,467	183,774	61,890	371,181	3,348	....	....	....	....	....	74.13	....	....	3.44	3.32	0.21	....	7.28	....	19.15	....	....	2. 18

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

Providence, R. I., August 9.—Owing to a misplaced switch on the Shore Line track to day, there was a collision between a freight train and an engine standing on a siding at this point. Engineer Rogers, of the standing engine, was slightly hurt by the shock, sustaining injuries to his foot.

Chattanooga, Tenn., August 11.—Charles Hardin, fireman on the Sequatchie Valley Railroad, a branch line of the Nashville, Chattanooga & St. Louis Railway, was watching the crew pull a car on the track by means of a wire rope, when the rope, which had a kink in it, snapped in two, one end striking him over the right eye, inflicting a terrible flesh wound.

Hartford, Conn., August 11.—Thomas Ford, a fireman on the New York & New England Road, was run over by a switch engine to-night, and will lose both legs. Upon coming in from Boston he was very tired and sat down in the roundhouse, just inside the door, to rest. He soon fell asleep and fell to the ground, with both legs across the rails. A switch engine backing in ran over him.

Colfax, Cal., August 14.—There was a collision in the snowsheds at Cascades, on the Central Pacific Railway, this morning at 11 o'clock. An extra train going east was run into by a work train. Engineer Isvard had his knee badly injured.

Oswego, N. Y., August 14.—A collision occurred between a freight and passenger train at Scriba, 6 miles east of here, on the Rome, Watertown & Ogdensburg Road, this evening. De Witt Gibbon, engineer of the passenger train, was found in the ditch, where he had struck when he jumped. He suffered from a dislocated shoulder and a bad scalp wound.

Fergus Falls, Minn., August 15.—A west-bound passenger train on the Great Northern collided with a freight at 3 o'clock this morning on the bridge across the Red River. No one was injured except the passenger engineer, and he not severely. The engine, however, was thrown into the river, where it is a complete wreck and partially covered with water.

Huntingdon, W. Va., August 16.—The first section of an east-bound freight train on the Chesapeake & Ohio Railway broke in two 13 miles east of this city shortly before 4 o'clock this morning, and the engine pulling the second section ran into the first. Engineer Hamilton and Fireman Lar, of the second section, were badly injured.

Baltimore, Md., August 16.—T. W. Brown, engineer on the Baltimore & Lehigh Railroad, was painfully and perhaps fatally scalded this afternoon at the North Avenue roundhouse, while making repairs to his engine. He was fixing a bolt under the boiler when a plug blew out, and he was instantly enveloped in a cloud of steam. He would have cooked alive but for the prompt action of his fireman.

Altoona, Pa., August 16.—Fireman Charles Miller fell from his engine last night while it was running at a fair rate of speed. In falling his head struck a tie and he was rendered unconscious, also sustaining severe cuts above and below his left eye.

Van Wert, O., August 17.—Engineer Fred Hall, of the Cincinnati, Jackson & Mackinaw Railroad, caught his feet in a hot-water pipe at Gilberts to day and was terribly scalded.

Dubuque, Iowa, August 17.—A passenger and freight train on the Chicago, Milwaukee & St. Paul Railroad collided 3 miles south of this city at 3 o'clock this morning. The engine and two cars went over an embankment. Fireman Samuel P. Kemp was injured.

Greensfield, O., August 17.—A freight engine on the east-bound track on the Baltimore & Ohio Southwestern Railroad exploded its boiler at Rock Bridge to-night, instantly killing Engineer Passam and Fireman Roberts.

Philadelphia, Pa., August 22.—The Norfolk express on the Wilmington & Baltimore branch of the Pennsylvania Railroad crashed into a freight train at Porter, Del., at 1.30 this morning. The cars were thrown from the track and the engineer and fireman were injured. The fireman's injuries are fatal.

Willimantic, Conn., August 23.—A head-on collision occurred between two regular freight trains on the New York & New England Railroad, 2 miles west of this place, at 12.40 this morning. The engineer and fireman of both trains escaped without injury. The fault lies with the night operator at Andover, who should have held the east-bound train until the west had passed, but was asleep. He has run away.

Belair, Md., August 23.—William Blaney, fireman on the Baltimore & Lehigh Railroad, was seriously hurt by falling from the tender of a locomotive to-day. His head was cut, and it is thought he has sustained internal injuries.

Brewsters, N. Y., August 26.—A head-on collision occurred this afternoon about 1 o'clock between Ice Pond and Dykemans, on the Harlem Road. Engineer Elliott, of Train 13, and N. Best, his fireman, D. Palmitier, engineer of Train 20, and Samuel Gibney, his fireman, were killed.

Milwaukee, Wis., August 27.—Passenger train No. 2, on the Milwaukee & Northern, or Lake Superior Division of the Chicago, Milwaukee & St. Paul Railway, was thrown from the track last night at Pike Hill switch, 185 miles from this point. A portion of the train was derailed, and Engineer Ainsworth had his right leg so badly crushed that amputation below the knee will be necessary. The fireman received slight injuries.

Norwich, Conn., August 27.—H. I. Read, a fireman on the Consolidated Road, nearly lost the sight of one of his eyes by the bursting of the sight-feed glass of the air-pump lubricator, by which several pieces of broken glass were thrown into and around one of his eyes. The eyeball is badly gashed, although it is hoped that the eye will be saved if inflammation does not set in.

Pittsburgh, Pa., August 29.—Fireman J. R. Earnest, on the Pennsylvania Railroad, was seriously if not fatally injured while making his run to-night. The train was running through Gallitzin tunnel when a stone from the wall fell and struck him on the head.

Middletown, N. Y., August 29.—Nathan Bryant, an engineer on the Port Jervis, Monticello & New York Railroad, was struck by an engine while walking on the track in Port Jervis this afternoon. He received several wounds and may have suffered internal injuries.

Newark, O., August 30.—Henry McGreevy, a fireman on the Baltimore & Ohio Railroad, jumped from his engine at Mt. Vernon to-night when the cars left the track. He was considerably bruised, besides having one shoulder dislocated.

Brenham, Tex., August 31.—A south-bound freight train loaded with merchandise was wrecked and partly burned 10 miles from here on the Gulf, Colorado & Santa Fé Railroad to-day. Jack Swanson, the engineer, was killed, and Fireman Dameron was fatally injured.

Baltimore, Md., August 31.—Through the carelessness of a flagman a collision occurred between a train on the Baltimore & Ohio Railway and a standing engine at Hanover and Wells streets this morning. As a result Engineer Maskell was badly scalded, and Fireman Sittler had his leg crushed to a pulp.

Springfield, Mass., August 31.—A Chicago limited express for Boston, on the Boston & Albany Railroad, broke through a frail iron bridge 1½ miles east of Chester at about 12.30 to day. Four Wagner cars were crushed and at least 13 persons killed, while many others were badly hurt. The bridge was being strengthened for heavy locomotives when the accident occurred, the workmen being at dinner at the time. The engineer, William Horton, was buried beneath the locomotive, and was very severely injured.

Albany, Ga., August 31.—The Cannon Ball train from Montgomery for this place met with an accident on a trestle just this side of Georgetown over Mercer's Creek. During the night a portion of the trestle was undermined and washed away. The damage was not discovered until the train was within a short distance of the point, when the engineer, realizing the great danger, told his fireman to jump. He applied the air-brakes and brought the balance of the train to a standstill just as he and his engine fell 45 ft. below. The fireman escaped with a few bruises, and, in spite of his terrible fall, the engineer was not seriously hurt.

Our report for August, it will be seen, includes 35 accidents, in which six engineers and five firemen were killed, and 18 engineers and 16 firemen injured. The causes of the accidents may be classified as follows:

Blowing out of plug	1
Breaking of wrecking apparatus	1
Bursting of gauge-glass	1
Caught by hot pipe	1
Collisions	11
Derailments	2
Explosion	1
Failure of bridges	2
Falling from engines	4
Misplaced switches	4
Run over	1
Struck by obstruction	2
Struck by train	2
Unknown	1
Washout	1
	35

DANGERS FROM REAR-END COLLISIONS.

To the Editor of the American Engineer and Railroad Journal:

In common with other readers of your valuable Journal, we have been greatly interested in the monthly account of "Accidents to Locomotive Engineers and Firemen," reported in your columns. These reports not only send a thrill of horror through sensitive souls, but shake the serenity of even the most stolid and indifferent corporations. They must tend also to arouse the practical mind to the fullest bent of ingenuity to devise methods of cure and prevention. Accidents will happen, must happen, in every human scheme, and perils are incident to the most perfectly devised human undertakings. The question is how to lessen their number and mitigate their horrors.

Since your Journal has taken up the problem with so much earnestness, and invited suggestions from every quarter, we respond with the alacrity born of assured experience. Theories on such a subject may be good, but demonstrated facts are better. We point to the facts.

It is well known in railroad circles that of all classes of accidents, rear-end collisions are among the most frequent and deadly. Statistics show this conclusively. Your monthly reports show it. Only last month several accidents of this nature occurred, accompanied by such harrowing details as these, which we find in your columns: "The engineer, fireman, and passengers"—one or many—"were literally cooked by the escaping steam, great pieces of flesh falling from them;" others were "injured for life," and the wreck rendered unapproachable by the scalding steam, so that nothing could be done to rescue the wounded or stop the destruction and damage to property.

Five or six years ago, a practical railroad man, realizing the perils from this cause, and moved by a recent disaster that cost the lives of more than a score of employés and passengers, besides hundreds of thousands of dollars in damages, set his brains to work to invent a safeguard. The result was the McDowell inside safety check-valve for locomotive boilers. As soon as it was completed your Journal devoted several columns of its valuable space to a full description and illustration. The device was soon after adopted by some of the largest and most progressive railroads of the country.

Since that time the McDowell check has grown steadily in official confidence and favor. The Pennsylvania Railroad equipped its whole system with it, and the Erie, Lehigh Valley, Philadelphia & Reading, Chesapeake & Ohio, Chicago Southside Elevated, and numerous other roads applied it. From every direction most gratifying reports have been noted of the efficient and invaluable service it has rendered. This device is still in the market, still accessible to all concerned, and it has become a standard appliance in railroad equipment.

The valve being located inside instead of outside the boiler, is absolutely protected in cases of collisions which break off the feed-water connections. In the event of accidents referred to, the valve closes automatically on the inside, thus effectually preventing the escape of steam. In other respects it meets all requirements of a perfect safety check-valve. While many railroads are now employing it, there are hundreds of others who have probably never investigated its advantages, and it is the purpose of this communication to stimulate, if possible, this wider inquiry in railroad circles.

It has been demonstrated, in more than one instance, that the presence of the McDowell check has saved to the company using it many times what it would have cost to equip every locomotive on its road with the valve. Leaving humanitarian considerations out of the question, saying nothing of the value of human life, economical and practical considerations alone should induce all roads to apply this simple, cheap, life and property-saving device. It may be said, in fact, that railroad employés and the public will sooner or later demand some such safeguard.

Yours respectfully,

J. M. Foster.

ARMOR TRIALS AT INDIAN HEAD.

To the Editor of the American Engineer and Railroad Journal:

The armor trials at the Indian Head proving ground, on July 11, are interesting, both from the splendid behavior of plate and projectile, as well as from the fact that the plate was thicker and the gun of larger caliber than had ever before appeared upon an American trial ground. It may also be said that the 17-in. plate represents about the maximum thickness of practicable armor. Beyond this point increased resisting power will be sought in an improved quality of metal rather than increased thickness.

The first trial was of a test plate of the *Monadnock's* 9-in. nickel steel armor, from the Carnegie works. The 8-in. gun, even with the reduced velocities employed, was more than a match for this thickness of plate, and all of the three projectiles fired got their noses through the metal. The interest of the trial centered, however, in the second plate, representing the barbette armor of the battleship *Indiana*. It was of nickel steel, from the Bethlehem works, and 17 in. in thickness.

In this trial the full weight, 850-lb. projectile was used, but the velocities were all below the capacity of the gun, beginning with 1,822 foot-seconds in the first and ending with 1,858 in the third shot. The penetrations were 16.6 in. for the first and 20 in. for the second shot, which fairly got its point through the plate. The third shot, with a striking energy of 21,000 foot-tons, made a clean perforation through the plate, passed through the 50-in. oak backing, a bank of earth, and disappeared in the woods beyond. The calculated steel penetration of this last projectile was 18.04 in.

The most remarkable and unlooked-for features of the day's trials were, that of the five projectiles recovered all were practically uninjured, and that in neither of the plates was a single crack developed. It is interesting to speculate as to the result had these plates been face-hardened—Harveyized. Cracks, no doubt, would have been produced by the terrific blows delivered, but it is not at all likely, judging from previous trials, that in any case would the projectiles have perforated the metal.

The preliminary trial of the Brown segmental wire-wound gun at the Sandy Hook proving ground calls attention to the fact that this type of gun is likely to be thoroughly tested in the near future. Beside the Brown gun, above referred to, the ordnance 10-in., cast-iron, wire-wrapped rifle is on the ground ready for trial, and it is understood that a Woodbridge 10-in. steel, wire-wound gun is also about ready for its test.

H. M. Califf.

MANGANINE.

On account of its high specific resistance and small negative temperature-coefficient, manganine, composed of copper, 83 per cent.; nickel, 4 per cent., and manganese, 13 per cent., is stated by a German electrician to be especially valuable in the manufacture of resistance coils. He found that after such a coil had been heated to about 212° F., its resistance was diminished by from 0.4 to 0.8 per cent.; but on repeating the process the alteration became less and less, until it amounted to no more than $\frac{1}{10000}$ of the whole. He recommends, therefore, that the coils should be heated to 225° and kept at that temperature for some hours every month, in order to get rid of the molecular disturbances due to the processes of manufacture, and that they should be well paraffined to preserve the alloy from air and moisture.

PROCEEDINGS OF SOCIETIES.

New York Railroad Club.—The New York Railroad Club held its first meeting of the season on Thursday evening, September 21, at the rooms of the American Society of Mechanical Engineers, which were filled. The discussions for the evening took a topical form, and that which attracted most attention was the inquiry into the advisibility of removing jacks, pinch bars, saws, and other heavy tools from the locomotives. Mr. Mitchell, of the New York, Lake Erie & Western Railroad, stated that the experience of that road was to the effect that jack screws and other tools which were kept upon the locomotive were liable to become wet through carelessness on the part of the trainmen in spilling water from the water tanks, and also from leakages from storms; furthermore, that the lighter tools, which were easily portable, were more than apt to be stolen either by employés about the shops or outsiders, who have no connection with the road. Under these circumstances the jacks were apt to become rusted, and in case of an emergency it was impossible to use them. They had, therefore, removed all jacks from the locomotives, and now kept two extra jacks at each station; and as the stations are not far apart, it is of course possible to obtain a jack by going a short distance for it. In place of these tools, the engine carried a full set of blocking, such as would be ordinarily required in case of accidents which are most likely to occur, such as blocking for holding the cross head in position, etc. Several of the members agreed that this was the simplest and

best way of handling these tools; but, on the other hand, it was contended by a number of members that these jacks were frequently wanted quickly, and that the emergency was often such as to render the delay of going to a depot a matter of life and death, especially where it is necessary to raise an engine or car from the body of a man who is pinioned beneath them.

Several members stated that they had no difficulty whatever in keeping their jacks in perfect condition and ready for use at all times. It was suggested that the imitation of European practice of keeping the jack on a running board and held in position by a bracket, where it will be in sight of inspectors at all times, and must be screwed down in order to keep it in position, was a good one.

Another topic for discussion was that of the advisibility of sending out engines with the eccentrics held by set screws alone. This practice was almost universally condemned, and all who spoke favored the use of keys very strongly. The objections that the key allowed of no adjustment of the eccentric in case it were desired, such as a variation of the lead, were met with by the fact that an off-set key could be very readily made and used. The use of keys driven in over a flat spot on the axle was not approved of. One suggestion was made as to the best way of holding the eccentric which seemed to meet with general approval. It was that the key should be let one-half into the axle and one-half into the eccentric. That two set screws should be used, and these should, in turn, be furnished with check-nuts, so as to take up what little variation there might be in accuracy of workmanship. After the eccentrics are in position, the two should be bolted together so as to prevent either one of the essentrics from shifting laterally until all of the screws had become loosened. With this arrangement it was contended that the eccentrics would give the best satisfaction. Some complaints were made that set screws that were tightened up and available to the engineer for such purposes would give trouble by springing the eccentrics themselves, causing them to heat. This had been the experience of several members. There were one or two other topics which were brought up for discussion, but they received practically no attention whatever.

Technical Society of the Pacific Coast.—At a recent meeting Mr. J. Richards presented a paper on Some Problems in Pumping Fluids, in which he made a comparison between the use of centrifugal and piston pumps, giving the former the preference in regard to economy of work and capacity. He said, in making this comparison, that a piston pump of 8 in. bore is set down for a duty of 120 galls. per minute, and a centrifugal pump of like bore at 1,200 galls. per minute, the proportion being 10 to 1. This comparison being made on the basis of flow capacity and with no reference to other efficiency or consumption of power in proportion to the work performed. In considering the question of cost, he stated that the flow capacity of 10 to 1 was qualified by the first cost of the two machines, which shows that a piston pump costs for a given volume of duty 20 times as much as a centrifugal pump. In respect to efficiency, or the consumption of power in proportion to the work performed, the difference in efficiency is also in favor of the centrifugal type. An evidence of this lies in the fact that the trade circulars issued include the efficiency of centrifugal pumps, but not of piston pumps. Contracts made for centrifugal pumps nearly always include stipulation as to the duty to be performed with a given amount of power, but this is not the case in respect to piston pumps of the commercial class, and their efficiency is, no doubt, much less.

The obstructions to efficiency, such as injuries, liability to derangement, steadiness of motion, and other features of this kind are in favor of the centrifugal pump. This comparison was made to show the economical difference between continuous and intermittent action, which is the chief distinction between these two methods of pumping. There is no reason why 1,200 galls. per minute should not pass through the piston pump, the same as it does through the centrifugal one, if there were not limitations of some kind that take away nine-tenths of the capacity of piston pumps. If we turn to the suction and discharge pipe of piston pumps, we find that they have a capacity of only one-third or one-fourth as much as that of the pump's bore, or comparing with centrifugal pumps about one-seventh as large, and are in proportion to the flow in the two cases. Here, then, is an anomaly: two machines for impelling water under like conditions for average heads, one costing twice as much as the other and performing one-tenth of the duty. The dimensions, weight, and first cost of pump machinery are inversely as the velocity with which the water passes through it. The limitation of duty in reciprocating piston pumps amounting to from eight-tenths to ninetenths of their normal capacity is due to the intermittent and irregular flow.

Professor Riedler, of Berlin, Germany, about 10 years ago began a series of investigations respecting the action of piston pumps, that with some other experiments of the kind is destined, no doubt, to cause a great change in practice. Professor Riedler's indicator diagrams taken from common pumps are monstrosities. No one would suspect that such flows as here appeared existed in pumps of any kind. The result of these researches was to increase the flow to 5 ft. per second, or about five times the former velocity, without the least shock or jar. They consist in positively operating the valves by mechanism independent of the action of the water, and so constructing water ducts that there is but little change of velocity as the water passes through the pumps. This system has also been adopted by Mr. E. D. Leavett in designing some pumps for the Lynn Water Works.

PERSONALS.

WILLIAM GREENE is now General Manager of the Cincinnati, Hamilton & Dayton Railroad.

D. G. EDWARDS has been appointed General Passenger Agent of the Cincinnati, Hamilton & Dayton Railroad, the appointment taking effect on September 1.

MR. THOMAS G. CLAYTON, of Derby, Superintendent of Car Construction of the Midland Railway of England, was among the passengers on the steamer *Lucania*. He comes as guest of his brother, Mr. James Clayton, President of the Clayton Air Compressor Works, New York. While here he will visit the World's Fair and make a study of the railway systems of this country.

LUCIUS TUTTLE, who has recently been elected to the Presidency of the Boston & Maine Railway, began work as a ticket clerk on the Providence, Hartford & Fishkill Railway in 1865, later was General Ticket Agent of this road at Hartford, going to Boston in 1878 as Assistant General Passenger Agent of the New York & New England Railway. Within a year or two he was General Passenger and Ticket Agent and Assistant to the General Manager of the Eastern Railway, serving on this road about six years. In 1885 he became General Passenger and Ticket Agent of the Boston & Lowell Railway, serving two years, and after the consolidation he became Assistant to General Manager Furber, of the Boston & Maine. In 1887 he became General Traffic Manager of the Canadian Pacific Road at Montreal. In 1889 he was made a Commissioner in the Trunk Line Association passenger department, and in May, 1890, he went to the New York, New Haven & Hartford Railway as its General Manager. In February, 1892, he was appointed its Vice-President, and has since held that position.

OBITUARY.

Charles Roberts Johnson.

To those who knew him only in business relations or by reputation alone, the name of Charles R. Johnson—whose death occurred at Saranac Lake in the Adirondacks of New York on September 11—will be associated with his occupation, which was that of a signal engineer, in which he was the most eminent authority in this country. Those who had the privilege of a more intimate acquaintance and friendship knew him not only to be a man of very marked ability as an engineer, but as a person whose character had a charm which attracted all who learned to know him, and were susceptible to the influence of a noble and generous nature.

He was a native of England, and was born in Higham Ferrers in Northamptonshire on January 17th, 1851. His father still survives him, and is William C. Johnson, who married Charlotte Sanders. The elder Johnson's first occupation was that of a builder, and later he was employed by the firm of Stevens & Sons, makers of railway signals in London.

Charles R. Johnson was educated at Dr. Pinches's academy in Kennington, London, and his first employment was in the drawing office of the City Architect in that city from 1867 to 1869. He remained there about two years, and then went into the employ of a Mr. Head, a builder, to make estimates and oversee work. When he was 23 years of age he made an engagement with the Messrs. Stevens & Sons, manufacturers of signals in London, where his father was employed. His work there was

to oversee the erection of signals. At the same time his uncle, Mr. Henry Johnson, was superintendent of the erection of work in the North of England, Scotland, and Ireland, for the celebrated firm of Saxby & Farmer, of London, the leading firm of signal engineers in England and probably in the world. This relation of the uncle led to an engagement of the nephew by the same firm, and in 1875 he entered their employ. He was at first associated there with his uncle, and had charge of the erection of work on different English railways. This gave him great familiarity with the difficulties and complications which are constantly encountered in adapting signals to the requirements of different locations and conditions. The amount of traffic on some of the English lines was then very much greater than on any of our American roads. Consequently systems of signals had to be developed and perfected there and adapted to the requirements of the traffic long before similar appliances were needed here. In putting up the signals made by Messrs. Saxby & Farmer, Mr. Johnson had the most abundant opportunity of becoming acquainted with all the multifarious details of their construction, the conditions they had to fulfil, the difficulties to be overcome, and the dangers to be guarded against. He therefore acquired a wonderful knowledge of the principles of railway signaling, and the intricacies growing out of a vast and complicated business which had to be controlled by the appliances which his firm were providing. He not only had charge of this work in England and Ireland, but in 1879 he was sent to France to superintend work which was done on some of the principal lines there. In 1880 he was sent to India as the representative of the interests of Saxby & Farmer in that country. While there he was much exposed to the influence of the climate, and contracted jungle fever, from the effects of which he never fully recovered. He remained in India only about a year, and then, owing to his illness, went to Australia, where he spent a few months, and then returned to England. This was in 1881.

Yours Sincerely
Charles R. Johnson.

To understand "the state of the art" of signaling in this country at that time, it must be remembered that interlocking and block signaling were then almost unknown here. In 1873 Messrs. Toucey and Buchanan, of the New York Central & Hudson River Railroad, erected a system of interlocking signals and switches at Fifty-third Street, where the incoming and outgoing tracks of the Grand Central Depot in New York crossed each other. The plans of this apparatus were brought to this country by two brothers named Brierly, who had been in Saxby & Farmer's employ in London, and it was a modification of the mechanism used by that firm. Later a similar interlocking system was put in at the Spuyten Duyvil junction of the same road. This mechanism afterward was much improved by Messrs. Toucey and Buchanan. During the Centennial Exhibition in Philadelphia, in 1876, the Pennsylvania Railroad Company erected some interlocking signals of the Toucey-Buchanan-Brierly system to control the traffic at the terminals of their line, adjoining the exhibition grounds, and a little later a Saxby & Farmer apparatus was placed on that road at the junction east of Newark, N. J.

The first use of block signals controlled by telegraph in this country was on the Pennsylvania Railroad about 1873. In 1876 Messrs. Saxby & Farmer exhibited at the Centennial Exhibition a very complete model of their system of interlocking signals, and also some of the apparatus employed in it and in block signals. It may be said that the acquaintance of many railroad men in this country with the systems of signals used in England dates from this exhibit. The need of better methods of controlling the movement of trains on our railroads had been experienced on many of our roads, and a number of railroad officers had attempted to evolve some system, adapted to their needs, out of their inner consciousnesses, or they sought the aid of some inventive genius to help them out of their difficulties. Some of these attempts were of a fearful and wonderful character. The imaginations of railroad men and inventors ran riot in devising different forms of targets, disks, and objects with length, breadth, and thickness to be used as signals. Under the circumstances which then existed, it now seems remarkable that railroad managers here, having experienced the need of more perfect and systematic appliances for controlling the movement of trains, were not disposed to profit by the knowledge and experience of foreign railroad managers in this direction. The demand for better appliances being apparent, it would be supposed that if there was any place in the world where more

complete systems had been used for a long time, and had been developed and perfected, that those who were without such knowledge and experience would be willing to profit by that which others had acquired. Human nature, however, does not seem to work that way. Innumerable failures seem to be needed to teach most of us—railroad managers included—wisdom, and incline us and them to be guided by those who know more than we and they do. It was so in this country regarding signals. In 1881 the Pennsylvania Railroad Company had experienced so much trouble with the crossing of their line with the Central Railroad of New Jersey at Elizabeth, and with other signal problems on their road, that they sent to Messrs. Saxby & Farmer and asked whether they could send a competent person to this country to advise them in regard to signaling. That firm recommended Mr. Charles R. Johnson, and it was under that engagement that he first came to this country. It may be said that he was the first engineer who was thoroughly and practically familiar with the systems in use in Europe, who was placed in charge of the construction of signaling systems here. On his arrival he made an investigation and report on the insoluble problem of the Elizabeth grade crossing and some other analogous subjects, and was then engaged by the Union Switch & Signal Company of Pittsburgh, which had been organized some years earlier, and had engaged in the manufacture of signals. During the first part of his engagement with this company he acted as a contracting agent for it, with his office in New York. Later he was made General Manager and removed to Pittsburgh.

In 1887 Mr. Johnson was married to Georgina Miller, daughter of Mr. George W. Miller, a noted lawyer of New York City. Mr. Johnson's character was well suited for domestic enjoyment, and from its beginning to the end his married life was to him an unfailing source of happiness, the delight of his friends in a like state and the envy of those who were less blessed. He was a member of the New York Athletic and Raquet Clubs, and of the American Society of Civil Engineers.

In 1888 an unfortunate disagreement with the officers of the Union Switch & Signal Company led to a separation, and Mr. Johnson then organized the Johnson Railroad Signal Company, whose works were established at Rahway, N. J., and of which he was the President and General Manager. The formation of this company was the realization of a dream which he in common with all ambitious men feel—that of being at the head of an enterprise of which they have the control. He worked at it with the energy which came from the hope of success and confidence in his capacity for achieving it. His expectations were not entirely unfulfilled. The enterprise was fairly launched and afloat and started on a prosperous voyage, when indications of failing health manifested themselves, at first at infrequent periods, which allowed him to give his time and labor to his much-cherished scheme; but just as success was assured, the warnings could no longer be disregarded, and in May, 1892, he gave up active business, and went to the Adirondacks with the hope that rest and out-door life would lead to recovery. Alternately hoping and fearing, he improved at times, but never quite recovered what he had before lost. His illness was long and sometimes painful, but he encountered that great enemy of the human race—consumption—with fortitude and resignation, and at last passed away peacefully. During all of his illness he was surrounded with friends who were very near to him, and was tenderly cared for. The last few months of his life were spent in a camp on Saranac Lake, where everything which could contribute to health or promote recovery was available. None of these were efficacious, and when the first autumn leaves began to glow with color, it was plain that the end was near, and on a quiet September day it came, and the life which had been so useful and made so many glad was ended.

The place where he died being accessible only by water, before the last solemn rites were observed the burial case was placed in a boat, and attended by those who were nearest and dearest to him, a sad train of frail vessels moved over the placid surface of the lake on a beautiful September afternoon, and thus began the journey to his last resting-place on earth in Mount Hope Cemetery in Rochester, N. Y., where he was buried.

Those only who had the privilege of intimate friendship with Charles Roberts Johnson can know how difficult it is to do justice to his character. Of his professional knowledge and ability little more need be said. The striking trait was the clearness and soundness of his judgment and opinions. He was not remarkable for ingenuity, and he once expressed thankfulness that he was not an inventor—the implication being that ingenuity was liable to interfere with or refract the inferences, opinions, and conclusions of an ingenious person, which unquestionably it often does. It may safely be said that in matters pertaining to his specialty of signal engineering there has never been any one in this country with as thorough a knowledge of that field, and whose opinions and advice could be so implicitly accepted.

As a friend and companion the charm of his character was indescribable. He was frank, generous, and thoughtful of the happiness of all. He was as considerate and courteous to his colored man who blacked his boots as he was to the president of a great railroad. While almost feminine in his tenderness, he had an amount of stored-up energy which was limited only by his physical strength. With a temperament which was cheerful under all circumstances, he was sympathetic and always ready to enter into the feelings and help those who were unfortunate. His ability and sterling integrity were recognized in many cases too late for him to reap the full benefit therefrom and which he had so fairly earned by an honorable life, by intelligent and faithful devotion to his occupation, to his patrons, his friends, and in some instances to his enemies.

He leaves a wife who, with many friends, will always miss his pleasant smile, his charming companionship, and the sincere affection in which they all had occasion to rejoice.

Hayward A. Harvey.

HAYWARD A. HARVEY, the inventor of the Harvey process for armor plates, died at his home in Orange, N. J., August 28, being in his seventieth year. He was the son of Brigadier-General Thomas W. Harvey, and was born at Jamestown, N. Y., January 17, 1824. His father was a millwright and inventor of the gimlet-pointed screw, the cam motion and the toggle joint; and 60 years ago built at Poughkeepsie the first machinery for making screws. Young Harvey, after getting an academy education, went into a New York company as draftsman, then took charge of a wire mill, entered into business with his father, and after his father's death in 1854 continued in the same line. During the 20 years, 1870–90, he gave practically all his time to the invention of machinery; but finding that certain experiments with steel showed promise of great success, he gave up everything else, and continued them until the great result was reached of a steel armor plate which now in its perfection sustains more and greater tests than any other. Mr. Harvey first and last took out about 125 patents, and dies with his name attached to the utmost achievements in the line of defensive armor for the navies of the world.

General Notes.

The Akron Tool Company, of Akron, O., have just received an order from the Chicago, New Orleans & Texas Pacific Railway for 30 of McNeil's patent balanced charging barrows for use at their coaling stations.

Pressure Regulators.—The Foster Engineering Company, of Newark, N. J., has just received, from the Consolidated Car Heating Company, of Albany, N. Y., an order for 50 pressure regulators for the steam heating of trains.

Latrobe Steel Works.—The recent report in one of the trade papers that the Latrobe Steel Works had shut down for an indefinite period, and had discharged its hands, is, we learn, without foundation, as they have been running continuously since their works were first started, and are prepared to execute all orders with promptness.

The Link-belt Machinery Company of Chicago.—This company has recently built and erected in the new retail store of Marshall, Field & Company, corner Washington and Wabash avenues, a Link-Belt elevator for handling boxes, bundles, etc., from the first to second and third floors. A like elevator to handle books and paper was furnished Shea, Smith & Company, printers, Chicago, for their new factory, while a similar outfit was built for the Chicago *Herald* some time ago for carrying folded papers from press-room to delivery-room.

The Stirling Company.—This company, whose shops are at Barbeton, O., have recently taken orders from the Minneapolis Electric Company for their water-tube boilers of 750 H. P., and a similar order from I. B. Mattingly Company, of Louisville, Ky. (a second order). The Taylor Chair Company, of Bedford, O., have also given an order for 150 H. P. More recently they report the following sales:

100 H. P. boilers for Salem, Mass.
400 " " " " Algonquin Coal Company.
250 " " " " Lutz, Libby & Co., of Park Place, Pa.

Like the boy who was fishing, they have a number of bites, and their agent, Frederick A. Scheffler, of 74 Cortlandt Street, New York, says: "Inquiries are coming to us to a greater extent than they did in July and August, which shows that business is unquestionably improving throughout the country."

Reading Iron Company.—This company wish the fact to be known that their "Scott Foundry Department" has one of the best-equipped foundries, machine and boiler shops in the country, and is prepared to undertake work of the heaviest character.

The machine shop is equipped with tools of the largest size, such as a 10-ft. planer, a 10-ft. lathe, 20-ft. boring mill, and 42-in. slotting machine, besides many special machines, such as a floor-boring machine, roll and gun lathes. The company is thus enabled to handle a class of work which comparatively few shops can execute. One of their specialties is the boring of long cylinders and axial holes through shafts.

In the foundry castings can be made of 40 tons weight. Besides cupolas it is equipped with three air furnaces from which charcoal gun-iron castings of the highest tensile strength are made. These castings, it is claimed, are preferable to steel castings for both steam and hydraulic cylinders, cranks, crank-shafts, gearing, cross-heads, and many other purposes.

In the blacksmith and boiler shops very heavy work can be done. The company operates its own blast furnace, rolling-mills, tube works, steam forge, foundry, and machine works.

Manufactures.

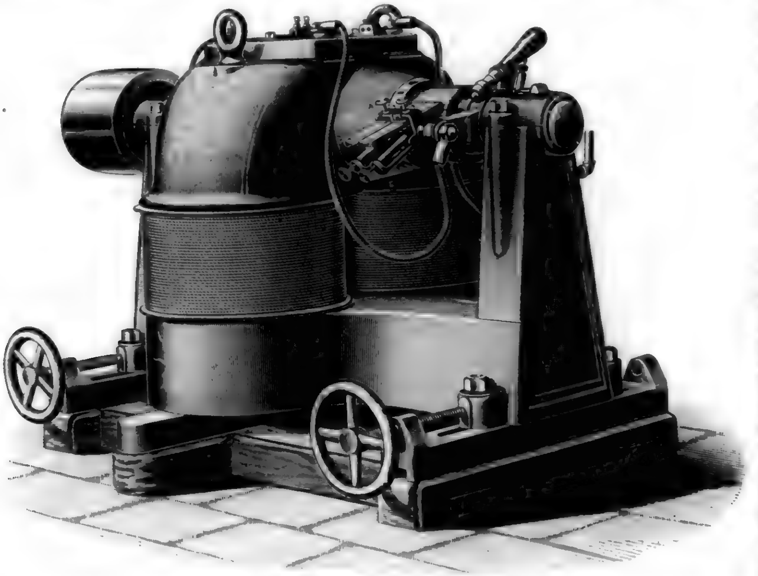
BELKNAP MOTORS AT THE FAIR.

The first of the exhibitors in the Electrical Building to complete their display were the Belknap Motor Company, of Portland, Me., who show a very interesting collection of motors, fans, generators, etc. The exhibit occupies Space 2, Section 3.

The apparatus shown is nearly all in actual operation, and is driven by a 10-H. P. 220 volt "B. C." (Belknap Standard) motor. This operates a 100 light standard dynamo of 110 volts. The current generated by this machine is used to operate the various pieces of mechanism, lamps, etc., comprising the exhibit. Prominent among the machines shown is a combined exhaust fan and motor of 1 kilo-watt capacity, running at 670 revolutions. The motor is multipolar, and can be run in either direction with equal efficiency. The combined machine has but two self-oiling bearings, one at either end of the shaft. The armature of the motor is built on a cast-iron sleeve together with the commutator and enclosing heads, so that it can be readily removed from the shaft by simply slacking a set screw. The armature core is built up of soft iron wire wound between the two end disks, the return wires being run across at 90° to adapt it to the four-pole magnet. A series of cross connections in the commutator permit the use of only two carbon brushes, also placed at 90° apart and situated in the most convenient position for adjustment.

A long-range spring is used for feeding the carbons, and the brushes require but very little attention. The field magnet consists of a single casting with a projection at the commutator end for supporting the bearings, and a part of this casting completely encloses the two field coils in such a manner as to protect them from injury. These are wound on metallic spools and are easily put in place or removed at will.

The generator also runs three motors of 5, 8, and 1 H. P. respectively, and also a little ¼ H. P. motor which operates a moving sign. This sign is in itself a striking feature of the exhibit. It is 8 ft. high and 5½ ft. wide, and consists of two frames separated at the bottom and resting against one another at the top like an easel, or, to be more exact, like a hen coop. On these frames are stretched the sign proper, having the name of the company in letters cut out of the background, and allowing a moving piece of canvas to be seen through them. This is painted in various colors horizontally and diagonally, so that when operated by the motor the letters constantly change color in unexpected ways. The same motor also runs two revolving fans at the top of the sign, each carrying colored incandescent lamps above the frame, as well as several inside to illuminate the perforated letters.



B. C. STANDARD 10 H. P. MOTOR.

Other important machines forming part of the exhibit are several "Cyclone" power mills electrically operated and made exclusively by this company.

Perhaps the most interesting device in the exhibit is a portable rotary electric drill with a magnetic attachment which holds it against the work while in operation. This machine is light enough to be easily carried in one hand, and is applied at once to any part of the casting to be drilled, the necessary power being taken from the nearest lamp-socket. It consists of a small electric motor made entirely of wrought iron, running at high speed and geared with a ratio of 1 to 10 to a spindle that carries the drill chuck, and has a sliding feather which allows it to move back and forth in obedience to a hand-feeding screw at the end. The frame for the support of the motor, spindle, and gearing is all of one iron casting. The drill is held against the work by a magnetic "sucker" consisting of a cup shaped piece of cast iron enclosing a coil wire taking its current from a shunt from the motor.

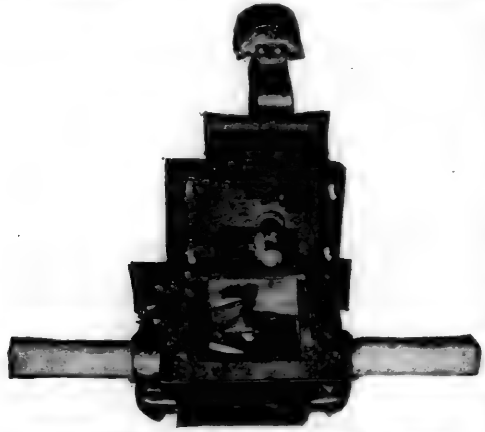
The same generator that furnishes the current to the motors, etc., also operates both arc and incandescent lamps about the space, while in the center stands a 250 light incandescent generator showing the company's workmanship in machines of this class. The Belknap Motor Company build dynamos of from 5 to 500 lights and motors from ¼ to 50 H. P. Their ammeters and voltmeters are also shown. Besides these there are specimens of combined dynamos and water motors, as well as a 60-light dynamo coupled directly to a high-speed engine built by H. R. Stickney, of Portland, Me., while a number of revolving fans on ornamental standards about the space kept things cool enough for comfort during the hot weather.

Mr. G. W. Brown, the President and General Manager of the company, is himself in charge of the exhibit.

THE UNIVERSAL ELECTRIC CONDUIT.

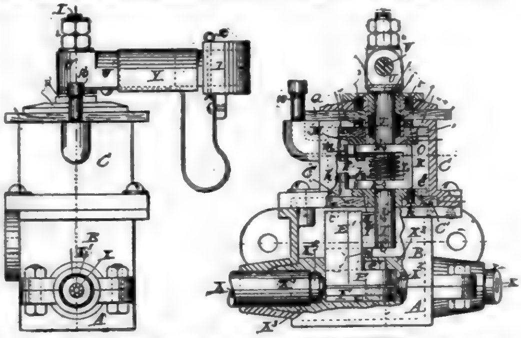
There has been on exhibition at Coney Island, during the past season, a short electric railway with a conduit for carrying and distributing electricity to the cars while in motion. The road that has been operated is the old right of way of the Boynton Bicycle Road, which is well known to all frequenters

of Coney Island. The conduit is of a very simple construction, and need be nothing more nor less than an opening in the street, with proper arrangements made for drainage. The insulated conductors are laid in the bottom of this conduit, and at intervals of 7 ft. are connected with a box from which the electric current is let out to the car. Two cables are used in the conduit, one being employed for the return current, as it has been found to be more reliable, and as causing less resistance than the ordinary return circuit through the rails. This does away with the necessity for bonding rails and all sparking between wheels and rails. The boxes from which the car takes its current are located in the track in question at 7 ft. intervals, alternated on the two cables, so that there is really a box every 3 ft. 6 in.; but in future constructions it is the intention of the company to place these boxes at 10 ft. intervals alternating, so that it will require but one for every 5 ft. of track. The arrangement by which the car takes the current is a very simple one. Suspended from the axle and free to move any amount in a lateral direction is a long copper-shod shoe that will be made but very little less than the total length of the car. This is suspended by two flat plates that come up through the slot in the conduit, which may be made of any width to suit the requirements of the franchise under which the road is to be operated. As this shoe is at least 10 ft. long under present conditions, and will be made from 16 to 20 ft. long under the new construction, it will be seen that it



DISTRIBUTING BOX OF THE UNIVERSAL CONDUIT.

is always in contact with the contact points from the box on each cable. The two sides of the shoe are insulated from each other, and are connected with the positive and negative contact points of the motor by way of the switch on the platform. The boxes which furnish the current for the car, to which we have made allusion, really constitute the keystone of the whole system, and are of an exceedingly simple construction. They consist of a cast iron box about 8 in. long and 4 in. square. The cable, which is insulated, enters the box, and for the distance through it is stripped so that there is a possibility of getting a contact with the wires. On this stripped portion of the cable a brass clip is fastened which is of a V shape, and in between the arms of the V there is a copper brush pivoted to a stem which rises through the top of the box, and which carries an arm shod with a copper shoe projecting out toward the center of the conduit; this brush is normally held by springs in a central position between the arms of the V, so that it is not in contact with it. The upper contact point, however, projects so far out toward the center of the conduit that the shoe of the car pushes it to one side and swings the brush around so that it comes in contact with one arm of the V; thus contact is made between the shoe and the cable. This, of course, as we have already pointed out, is done on either side, making a contact with the two cables. The bottom of the box is filled with a solid paraffine and the other with a liquid paraffine oil, which tends to preserve the insulation. The only point where there would be the slightest possibility of leaking would be down at the stuffing-box about the spindle which rises from the brush. This is carefully protected by a specially designed stuffing box, and experiments have been made by which it is shown that there is no perceptible leakage, and it is claimed that the delicate instruments within, in testing the current, do not indicate any loss whatever. A test was recently made on this road in which the conduit was filled with mud and water to its surface; the car ran into this mixture, stopped and started again, and ran backward and forward, showing that there was an ample current at all times for the movement of the car. The voltage at the time showed about 300 at the starting-point. The road which has thus far been operated has, of course, been merely an ex-

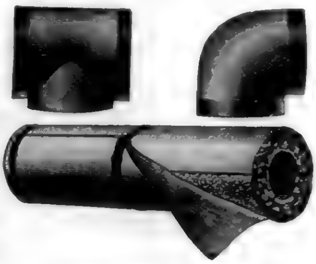


SECTION OF DISTRIBUTING BOX OF THE UNIVERSAL CONDUIT.

perimental affair, but it is intended to make an application of the system very shortly to a road working under ordinary conditions, and give the system a thorough trial through the winter.

ASBESTOS PIPE-COVERING MATERIALS.

In a communication made some time since to the Michigan Engineering Society, Mr. William E. Cooley reported his experience with coverings for steam-pipes. As an instance of the value of steam-pipe coverings, he cited the case of an electric-lighting plant at Ann Arbor, where there was about 60 ft. of 7-in. pipe connecting the boiler with the engines. When this pipe was first put up the steam at the further end from the boiler was tested to determine the amount of water entrained, and the average of nine experiments gave 31.01 per cent. of moisture. A few months later, when the pipes had been covered, the quality of the steam was again tested, and the average of five experiments gave 3.61 per cent. moisture. The tests were made by the same men, from the same connections, and in the same manner. The quality of the steam at the boilers was tested, and gave about 3 per cent. of moisture at the later experiments, showing that only .61 per cent. of moisture was developed by condensation in the pipes at that time. From this he made a calculation assuming that 100 indicated horse power were to be developed, and that each horse power would require 30 lbs. of steam; then if the steam is assumed to have 35 per cent. of entrained water due to condensation, 4,000 lbs. of steam will need to be produced in the boiler, or 1,000 lbs. more than necessary. To produce this would require about 125 lbs. of coal per hour, costing $450 per year, which would pay 6 per cent. interest on $7,500, whereas the cost of the covering did not exceed $150.



ASBESTOS PIPE COVERINGS.

The illustrations accompanying this show the asbestos pipe covering which is manufactured by the H. F. Watson Company, of Erie, Pa. This covering, as shown in the illustration, is what is known as the molded type, but it is also made woven, so that it can be wrapped about the pipe like a felt covering. This molded covering is made of asbestos fiber and other non-conductive materials, which fit pipes of varying diameter from ½ in. upward, and it is shaped to fit elbows, T's, and valves. It is so arranged that it can be applied by inexperienced workmen, and whether the pipes are hot or cold, it will stand all temperatures of heat or cold without cracking or crumbling, and is covered with a canvas jacket which can be removed without injury or waste.

The firm also manufacture the boiler covering or lagging that is of essentially the same formation as the woven covering to which we have already referred, and is furnished with or without a canvas jacket, which can be fastened or applied by using staples, or the sections can be laced together. The advantages of this style of boiler covering is, that when cement or plaster work is removed for repairs to the heated surfaces, it has to be replaced with new materials, whereas this can be laid aside, the work completed, and the same section replaced. The elasticity is another good feature, which allows the covering to be shaped to fit almost any irregular surface. As a covering for locomotive and marine boilers it is especially suitable, and has advantages which recommend it for these uses. It will not crumble or fall away when subjected to the constant jarring of engine work, and will remain as firm and useful as when applied.

In addition to other boiler and pipe coverings, the same firm also manufactures asbestos roofing and also asphaltum covering and tarred felt for the same purposes. Their asbestos manufacture also includes a plastic stove lining, a furnace cement, and asbestos mill board, together with various forms of sheathings and coatings.

COMPARATIVE TEST OF THE WESTINGHOUSE AIR BRAKE COMPANY'S NINE AND ONE-HALF IN. AIR PUMP AND THE NEW YORK AIR BRAKE COMPANY'S NO. 2 DUPLEX AIR PUMP.

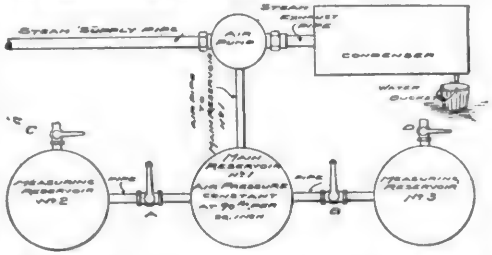
THE following is the average result of a series of comparative tests to ascertain the relative efficiency of the Westinghouse Air Brake Company's 9½-in. simple air pump and the New York Air Brake Company's No. 2 duplex air pump, the latter having two 7-in. steam cylinders and two air cylinders 10 in. and 7 in. respectively in diameter. The test was made by the Westinghouse Air Brake Co.

NAME OF PUMP AND SIZE.	DUTY required to raise the pressure from atmospheric pressure to 85 pounds per square inch in one cubic foot of space, pumps working against a constant pressure of 90 pounds per square inch in main reservoir; steam pressure 140 pounds per square inch.		Piston Travel in Feet, per Minute.
	Time per Cubic Foot of Air.	Steam per Cubic Foot of Air.	
The Westinghouse Air-Brake Company's 9½ in. simple air pump (one steam and one air cylinder)..........	8 $\frac{928}{1000}$ seconds.	2 $\frac{732}{1000}$ lbs.	118 ft.
The New York Air Brake Company's "No. 2 duplex" air pump, two steam cylinders 7 in. diameter and two air cylinders 10 in. and 7 in. diameter	10 $\frac{836}{1000}$ seconds.	2 $\frac{755}{1000}$ lbs.	179½ ft.

Temperature of air at air discharge pipe connection, after the pumps had been in operation 56 minutes: Westinghouse 9½ in. pump, 442°; New York No. 2 duplex pump, 515°, when the New York duplex pump had to be stopped on account of the air cylinder heating badly, while the test of the Westinghouse pump was continued through a period of one hour and fifty minutes, at the expiration of which the temperature of the air had risen at the discharge pipe to 470°, which in nowise prevented a prolongation of the test, had such been desired. Both pumps were run at full speed, with throttle wide open.

In these tests the pump was coupled to a main reservoir in which a constant pressure of 90 lbs of air was maintained. Communication was made from this reservoir to another of known capacity by means of an opening of a size adjusted to equal the capacity of the pump, so that the pressure was maintained continuously in the first reservoir at 90 lbs. Air was allowed to flow into the second reservoir until it reached a pressure of 85 lbs., when communication with the first reservoir was cut off and the connection made between the first reservoir and the third, of the same size as the second, while the latter was being emptied. By thus alternately filling and emptying the measuring reservoirs it was possible to maintain a uniform resistance on the pump, and to accurately measure the quantity of air delivered in cubic feet. The consumption of steam required to do this work was determined by connecting the exhaust of the pump with a surface condenser, which condensed all of the steam into water. The weight of water used during the period of the test is an accurate measurement of the steam consumed.

The following diagram shows the arrangement of pumps, reservoirs and condenser used in making these tests, and we believe this is the only exact method of making comparisons; and as the method is so extremely simple, we have no doubt that when understood it will be used when comparative tests of air pumps are being made.



NOTE.—Cocks *A* and *B* are graduated so that when opened alternately to fill either measuring reservoirs No. 2 or 3, as required, 90 pounds air pressure is constantly maintained in reservoir No. 1, and as each of No. 2 or 3 are alternately filled to 85 pounds air pressure, cocks *C* and *D* are opened and the reservoirs emptied. The number of measuring reservoirs filled within a given time to 85 pounds pressure is therefore the measure of work each pump is capable of performing as a product of the relative amount of steam used and condensed into water for convenience of measurement by weight.

The results, as given, are the average of a number of carefully conducted tests made expressly for the purpose of determining the relative capacity and economy of each pump, and show the Westinghouse 9½-in. pump to be 17 per cent. superior in capacity and .023 per cent. in steam consumption to the New York No. 2 duplex air pump, while the rate of piston travel of the duplex was 52 per cent. more than the Westinghouse pump.

The construction of the New York duplex pump is such as to be liable to produce a final temperature of the air under compression and air cylinder that is destructive of packing and lubrication. The Westinghouse Air Brake Company has made exhaustive experiments with duplex air pumps, in which the steam cylinders were compounded as well as the air cylinders, thereby securing the economy due to the expansion of steam in cylinders of different sizes. It was found by experiments carried out, as already described, that the consumption of steam per cubic foot of air was less than two lbs., but that the excessive heating of the air cylinder was the same as with the New York duplex pump; and after a most careful investigation they came to the conclusion that the considerable gain in economy in the use of steam did not compensate for the objectionable use of practically two complete pumps, where a single pump would perform the service with considerably less cost for maintenance.

WORLD'S FAIR ROUTE.

FOUR HUNDRED MILES AS THE CROW FLIES

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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EDITORIAL NOTES.

THE possibility of coaling steamers at sea seems likely to be one of the realizations of the near future. Very successful experiments have recently been conducted both by the British Admiralty and the Navy Department of this country. In both cases it is reported that the work was successfully accomplished, though modifications in the mechanisms employed have been suggested. When the work can be done the effectiveness of cruisers and of a blockading squadron will of course be very greatly increased, and the range of sea covered be correspondingly widened.

ONE of the notable events in army circles promised for the near future is the test of the rapid-fire 6-pounder and 4.7 in. caliber rifles at Sandy Hook. Arrangements have been made to hold these trials at some time during the present month; but when we take into consideration the fact that the guns were on exhibition at Chicago up to the closing of the Fair, and that they must then be packed and shipped to Sandy Hook, it is not at all probable, although it is possible, that any work will be done before December 1. However, the trial is not far distant, and when it does come off we may look for some astonishing results in the effectiveness of the weapons that have been offered for the competition.

A PROPOSITION has been made with the view of increasing the efficiency of our weather bureau by the establishment of a telegraphic or telephonic communication with the various lightships that are anchored off the coast. Thus, were such a communication to be established between the shore and the Nantucket lightship, it would be possible to obtain news of incoming European steamers several hours earlier than is possible under the present system, besides enabling the ship to signal the approach of storms to passing vessels, which are now wholly without such warning. This naturally has suggested the mooring of vessels along the transatlantic track, which naturally appears impracticable, whereas the establishment of communication between the lightships and the shore seems to be entirely within the bounds of practicability, and the results obtained would certainly be of the highest value.

A REFERENCE to our list of accidents to locomotive engineers and firemen for the month of September shows an increase in the number of collisions over that of preceding months, which suggests the advisability of a better system of signaling than that which obtains on most roads, as well as an improvement in the training and discipline of the train crews. Where the traffic and the finances of the company will not warrant the installation of an interlocking system of block signals, there should be a rigid insistence on the careful execution of the rules regarding the duties of the rear flagman and the switchman. It is inexcusable that a switchman should open a switch in the face of an express train, as was done in the case of one of the accidents in the list referred to.

THE success which seems about to crown the efforts of the Navy Department in securing a practical submarine torpedo boat has set a host of inventors busy in devising schemes for submarine navigation. One, with a boldness deserving of a nearer probability of success, has even gone so far as to propose a submarine electric trolley line for transatlantic service. Thus in one fell swoop he breaks the record of the time of the passage, removes the horrors of seasickness and realizes the machine of Captain Nemo. Of course the details of the work have not yet been developed, but a New York daily has given the scheme publicity, and the mere matter of detail is a trifle beside the conception. We do not like to promise our readers that a full description of the methods to be employed are to be forthcoming at once, but we will watch for them with a deal of interest.

A STRANGE oversight has occurred in the designs of some of the vessels recently designed for lake service. In the desire to secure the greatest possible cargo-carrying capacity, the depth over the sill of the Ste. Marie Canal and the breadth of the lock has apparently been the only point considered. The new vessel, the *Centurion*, illustrated in this Journal in April, 1893, is 379 ft. long, and has a capacity of 155,000 bushels of grain, yet the limitations of river navigation have been overlooked, and on a recent trip to Chicago a number of piles had to be pulled in the Chicago River in order to get her to the dock. There is no good reason apparent why any size of vessel that can be floated should not be navigated through the lakes; but until changes are made in the harbor facilities of such ports as Chicago and Cleveland, the growth of lake freighters will probably be at a standstill.

DETENTIONS ON RAILROADS FROM DEFECTS IN LOCOMOTIVES.

IN these days of frequent and appalling railroad accidents, any earnest and rational effort to indicate the primary causes to which they are due should receive more than ordinary attention. Hardly a day passes now without an account of one or more accidents in the daily papers, the horrible details of which must make every sensitive reader shudder. While we are boasting over the magnificence of our great Exhibition, disasters are occurring on our railroads which are spreading mourning through the land, and are sufficient to excite the indignation of the whole people, and should drive some of our railroad managers into the ashes and sackcloth of humiliation.

On another page a table will be found which gives the statistics of the defects in locomotives which have caused detentions on one of our prominent roads. For the present the name of the road will not be made public, the immediate purpose being to call out similar records from other roads for purposes of

comparison and comment. The road from which our record has been obtained is not an easy one to operate, and its topography would not lead one to expect an exceptionally low rate for locomotive failures. The road has nearly a thousand locomotives, many of them over 20 years old.

If a record of this kind could be supplemented with full data and sketches showing the character of the failures, with dimensions of the parts and full particulars of each, it would add very much to the value of the record, and would be extremely instructive. We are in hopes that the publication of the table may induce some one at some future time to supply such further data as we have indicated. Records of this kind have been kept on some roads. Their publication would be a public benefit. With the mere figures of the number of failures before us comment must, to a very great extent, be blind. Nevertheless, the mere numerical data are significant in many cases.

The most prolific cause of detention, it will be seen, is due to the failure of the springs and their attachments, such accidents amounting to nearly 15 per cent of all; the breaking of spring hangers and bolts alone amounting to nearly 10 per cent. With complete data of the nature of these failures and knowledge of the construction of the engines on the road, it ought to be possible to show the design, construction, and proportions of the parts which are most subject to failure. The moral of the investigation would be to abandon and avoid the forms, proportions, and designs of those parts which fail most frequently.

We confess to some surprise to see that the second most prolific cause of detention was due to failures of grate arrangements. One feels about this part of the report as the woman did who asked a man with only one leg how he lost the other, and was told "it was bit off." We have a consuming desire to know how the grates failed. Was it due to the burning of the bars or to the mechanism by which they are supported and operated?

Another surprise attends the figures showing the detentions from the failure of eccentric straps and rods, which sum up to a total of 115. The failure of eccentric bolts—which, we take it, means eccentric strap bolts, although it may be the bolts by which the rods are attached to the straps—amounts to 57. This would seem to indicate insufficient strength in these parts. The breaking of rods and straps is often due to neglect in oiling, and probably the bolts fail at times from the same cause. If this neglect is the principal cause, it would seem to be a strong argument in favor of some form of valve gear outside of the engine, where it would be more accessible for oiling and examination than eccentrics are which are inside.

The next most prolific cause of detention is the breaking of cross-head gibs and bolts, to which 66 cases are assigned. This report also excites one's curiosity to know what kind of gibs and bolts failed, and how. Are the failures due to defective design or construction or to imperfect lubrication? The cure for the evil must depend upon the cause to which it should be assigned.

Fifty-nine detentions were caused by the breaking of main connecting-rods or their parts; 36 of these were due to the failure of straps—the moral of which would seem to be to abandon their use. The fracture of gibs, keys and strap bolts is charged with 19 detentions. Only 4 main rods broke.

Defects in side or coupling-rods and their attachments caused 30 detentions, their straps and bolts being again responsible for much the greater part of the breakages. This emphasizes the importance of abandoning the use of straps. The comparatively small number of breakages of coupling-rods, only 7, may be noted. Probably a much larger number of fractures of coupling-rods in proportion to the breakage of main connecting-rods would have been anticipated.

Forty-one piston-rods broke, which seems to indicate that they should be made larger; but an investigation and test of the strength of the material of those which failed would throw some light on the cause.

The failure of air pumps to work is charged with 53 detentions. This seems to indicate that there is room for improvement in the design of these machines. If their construction was open to free competition, as it probably will be before long, the process of evolution would be likely to produce a machine less liable to fail. Considering how short a time air pumps have been used on locomotives, it is perhaps not remarkable that they have not yet reached complete perfection.

It will be seen that 37 steam chests burst, which suggests the question whether a stronger form could not be designed. The weakness of a cubical-shaped vessel for resisting internal pressure is obvious. Cross stays are impracticable in a steam chest, so that the flat sides and top must be strengthened with ribs to resist the strains to which they are subjected. Cylindrical steam chests for piston valves have, in this respect, an advantage. If the practice were not so common, it would seem like very bad engineering to make a box with flat sides to resist the internal pressure which steam chests must often stand. The design of a new or improved form for these vessels, better adapted to its purpose than those which are now so generally used, is an interesting problem for some of our ingenious designers to study over.

Thirty-eight piston-rod glands and studs for same broke. This was due doubtless to improper screwing up of the bolts. If an engineer finds that his packing leaks, his first impulse is to screw up the bolts. If the leak is not stopped, he screws them up a little more, and may repeat this several times, with perhaps an accompaniment of language not proper to print here, at the same time forgetting, or not stopping to inquire, whether the packing has been in use so long as to be solidified to a degree equaling that of wood or stone. The bolts are unduly strained or the gland "canted," and a break naturally follows. The use of metallic packing seems to be the remedy.

Twenty-nine driving axles broke. It is not said how long they are allowed to remain in service before being removed; 22 driving boxes and 21 springs also failed. The latter, if added to the failure of spring hangers, etc., makes these parts by far the most frequent source of detention, and naturally leads to an inquiry whether improvement is not in some way possible. Students of English rolling stock must have noticed that, notwithstanding the average condition of their roads is better than ours, the general practice there is to use longer springs than we do. May it not be, in view of the record before us, that it would be well for us to follow their practice in this respect?

Only 4 engine truck axles are reported as broken; but again the untrustworthy springs are credited with 12 detentions. These, with 3 failures of tender springs, make a total of 221 detentions, or nearly 17½ per cent. of all were due to the breakage of the carrying springs or their attachments.

Engine frames seem to stand the wear and tear better than would be expected when their size, the importance of the functions they must perform, and the strains to which they are subjected are taken into consideration, as there were only 24 breakages.

If we leave the eccentrics, their straps and rods out of consideration, it is surprising how seldom the valve gear gives out. It is charged with 4 broken lifting shafts, 1 link, 2 hangers, 4 valves, 5 valve stems, and 9 valve yokes—25 failures in all.

Piston packing rings are charged with 13 failures, piston heads with 8 and piston keys with 15, or 36 in all.

Twelve pulling bars and bolts broke, which would seem to indicate insufficient strength.

Fourteen rocker arms and 1 rocker bolt failed, which some

of our English friends may quote against us, although, as a general thing, there is no working part of a locomotive which costs so little to maintain as a rocker.

Of the small number of tender truck axles broken, only 3 will be noted, and only 7 detentions were caused by broken or loose engine tires.

It should be said that, as we understand it, the breakages recorded in our table do not show all those which occurred on the road, but only those which caused detentions. Our comments are intended to direct attention to those features in locomotive construction which seem to need improvement most. The record seems to be a remarkably good one, and if we were able to compare it with similar records from other roads, which we invite, the comparison would be very instructive.

ASPIRING MERIT.

To most people possessed with the right kinds of heads and hearts, it is always a satisfaction to recognize and aid those who are ambitious, but unknown. We are in receipt of a communication from a rural post-office which seems to give us such an opportunity. Our correspondent says :

"I am looking for a situation at working for and traveling with some surveying or photographing party, or party who is locating new carriage roads or railroads, especially among picturesque natural scenery, where it would be good views for photographing, etc., and I claim to have the following points :

"1. I can prove that I am strictly honest in every respect.

"2. I am very ingenious in mechanical and machine work, and an inventor.

"3. I have had a great deal of experience in camp-life, carrying, moving, building camps of various kinds, and know just what is required in a camp (except cooking—that I do not know much about), but I do know what groceries, provisions, bedding, tinware, hardware, clothing, tools, implements, boat fixtures, carrying apparatus, etc., is needed in camping and traveling far away from civilization, as I have traveled all over the Adirondack wilderness during six years, and visited over 300 of its lakes and over 400 of its mountain peaks, which you can judge requires a great deal of climbing over, through, around, under, up, down, into, along, across, onto, between, and by the side of a great many ledges, swamps, windslashes, burnt timber, underbrush, wet places, streams, cataracts, rapids, ponds, lakes, beaver meadows, still waters, hills, ravines, mountains, slides, rocks, thickets, berry brush, sand, plains, mossy and wet hard head-stones, mud quicksands, shelving rocks, ledges, etc., fallen timber, alders overflows, all of which makes me good at locating roads, canals, bridges, paths, etc., among such places, when combined with the great taste I have for such work and of locating them where they will run in view of the most picturesque natural scenery possible, as that is a good thing, especially on a toll road or railroad, to attract travel. There is nobody likes picturesque natural scenery more than I do.

"4. I am first-class at repairing any mechanical object that needs it.

"5. I am tough and healthy, and am not afraid of catching cold by sleeping out-doors or wading water or traveling at any time of the year (but prefer a mild climate in winter, such as California, Oregon, Washington, Nevada, Idaho, Montana, Wyoming, Colorado, New Mexico, Arizona, Texas, North Carolina, Tennessee, Kentucky, Virginia, West Virginia, etc.).

"6. I am good at keeping accounts, figures, etc., good memory, prompt in correspondence, systematic in doing business, etc. (which is more than you can say of most men). Age, 31.

"7. I can give hundreds of the best of references to prove all this."

This statement of his qualifications is followed by about two pages of references, and our unrecognized genius says he can give hundreds of others, and adds, "They, of course, do not know all my good talents, knowledge, and taste for the work I ask for, but are *acquainted by sight at least.*"

He gives his ideas of the proper way to locate roads, and they—the ideas—are—and doubtless the roads would be—good.

To show the probity of the applicant for employment, he says, "I enclose two stamps for a reply." The stamps were there.

By reading between the lines there are indications of clear grit and sterling character in our correspondent's entertaining letter, and we will take pleasure in giving his address to any one in need of such services as he is anxious to render.—EDITOR AMERICAN ENGINEER.

NEW PUBLICATIONS.

THE NEBRASKA CITY BRIDGE. *A Report to Charles E. Perkins, President of the Chicago, Burlington & Quincy Railroad Company.* By George S. Morison, Chief Engineer of the Nebraska City Bridge. (13¾ × 21¼ in., 68 pp.)

This is the latest of Mr. Morison's splendid reports, for which he has become famous. It begins with a photogravure showing an excellent view of the bridge. This is followed by a preliminary narrative, a general descriptive table showing the cost of the pneumatic foundations, masonry and piers. A description is then given of the superstructure, the weight of materials used, the date of erection and cost. Similar data are given with reference to the approaches and protection work and the cost of the whole structure, which was $582,790.87, to which $18,346.12 more was added for the highway accommodations. A list of engineers, employés, and contractors, and the act of Congress authorizing the construction of the bridge, and the contract with the War Department are given in an appendix. Other appendices contain, Specifications for Masonry, Records of Sinking Caissons, Time, Cost, and Materials Used in Foundations, Specifications for the Superstructure, and Records of Tests of Steel Bars.

The succeeding engravings consist of an excellent full-page map showing the location of the bridge ; a general elevation, plan, profile and alignment ; views of the abutments, and another page showing the piers, a diagram showing the rate of progress in sinking caissons, and another which is a record of water stage in the river during the erection of the bridge ; 12 full-page photo lithographs of details of the bridge, and two full-page strain sheets.

The paper, press-work, typography, printing, drawing, and engraving leave nothing to a reviewer to suggest, criticise, or desire. It is a very valuable record of an important work.

TRANSPORTATION. Vol. I, No. 1.

"We old fellows," who have been grinding in the editorial mill for, lo ! these many years, do not cease to wonder at the courage and temerity of younger and less experienced men who launch new vessels into a stream already crowded with various kinds of craft, some of which, if current report be true, have difficulty in keeping afloat. "But hope springs eternal," etc. It thus happens that Mr. William Morris Hayes, Conductor, Editor and Publisher, and H. W. Spofford, his assistant, of New York, have concluded, as they say in their announcement, that "with all the journals now published devoted individually to the special subjects covered by *Transportation*, the field is not fully occupied." Those of us who have borne the burden and heat of these many days cannot read this without ejaculating, if it is not now fully occupied, then "Good Lord, have mercy on us !"

It is ungracious, though, not to welcome new-comers ; therefore we extend the hand of journalistic fellowship to *Transportation*. Its editors have engaged in a great calling, in which either a splendid success or miserable failure are possible. It is a road in which fortune and salvation can be achieved, or which may lead to poverty and the damnation of the souls of the editors. Perhaps at the outset of their careers a little patriarchal advice to the conductors of a new venture may not be out of place. Advice and small-pox are alike in this, that they are given more willingly than they are received, and the former is unlike deeds of charity, in that the blessedness of it consists in the receiving and not in the giving.

There is every reason for thinking that our young aspirants to journalistic fame intend always to speak, and write the truth. Probably, though, they do not realize how strong the temptation will be at times to depart therefrom. They may be assured, though, that unless they adhere strictly to the maxim of a distinguished journalist, "Never to print a paid advertisement as news matter," it will be impossible to maintain their veracity. They may disregard that injunction once, twice, perhaps a dozen times without departing from strict integrity ; but they may be assured that if they persist in publishing paid advertisements as editorials or news matter, that sooner or later they will lie like gravestones. The old-fashioned people tell

us that sheol is the ultimate destination of people who are given to this. Whether it is or not should not lessen the significance of the example of Ananias and Sapphira to young editors and old ones as well.

Success in journalism at the present day requires many and diverse qualifications, some of which are not of a very high or ennobling order. We have not time nor room for a disquisition on "the elements of success in technical journalism," although an interesting essay might be written on that subject. We trust, though, that our new contemporary may deserve and have success. It may not be amiss to remind them though of the ill effects of mixing beverages, and to advise them not to allow their advertising columns and editorial pages to commingle, the moral effects of which are worse than those of mixed drinks. Read the ten commandments occasionally, and then "hustle."

The Law of Incorporated Companies Operating under Municipal Franchises, such as Illuminating Gas Companies, Fuel Gas Companies, Electric Central Station Companies, Telephone Companies, Street Railway Companies, Water Companies, etc. By Allen Ripley Foote and Charles E. Everett. Robert Clarke & Company, Cincinnati.

The authors of this work have undertaken, with the aid of a co-editor in each State, to present a short historical sketch and an outline of the laws of each State relating to corporations operating under municipal franchises, special attention being given to the kinds of corporations enumerated in the explanatory portion of the title. The important changes in the constitutional, legislative, and judicial policies of the various States toward such companies is traced in brief, and the main provisions of the laws now governing and regulating the organization and operation of such corporations presented. The names of the co-editors include not a few well-known lawyers, and the several compilations appear to have been well made.

This portion of the work is evidently intended as a handbook for lawyers, and also for municipal officers and other laymen who may have to deal with the subject. Good lawyers will, of course, use it as they use all text-books, only for suggestions of general principles and for references to the original, constitutional, and legislative provisions and judicial decisions, and for these purposes will find it of value. It will, however, be particularly interesting and valuable to laymen who do not have access to the original sources. When they wish to go to the latter or to determine nice questions of law in reference to municipal franchises, they will still be compelled to consult lawyers.

These historical sketches and compilations of the laws of the several States are preceded by a discussion by Mr. Foote of the economic principles involved in the operation, control, and service of such companies. The author says of his purpose in this discussion, "I have sought to elucidate principles and clearly to define strategic points in order to measure by fundamental rules the progress made by the several States in aligning legislation with the requirements of such rules. My purpose has been to outline the subject in a way to induce others to engage in an exhaustive discussion of the fundamental principles upon which municipal, political, and industrial corporations must be founded, if citizens of municipalities are to enjoy the greatest obtainable advantages from the use of modern municipal conveniences. . . . No general question of governmental policy occupies at this time so prominent a place in the thoughts of the people as that of properly controlling without unnecessarily checking the growth of corporate power."

Thoughtful readers will differ widely from each other in their views of the success of the author in accomplishing his very laudable undertaking. There is, however, much in this discussion which our mayors and aldermen and embryonic statesmen, and even an occasional United States Senator, might ponder with profit. For example, there are some good old doctrines relating to labor and property set forth by the author in Chapter IV of the treatise with great clearness and force. "The freedom of labor is inseparable from the freedom of contract;" "A contract that binds one party to pay a certain consideration as the full price of labor performed, binds the other party to accept such payment in full for service rendered;" "By assuming the risk of loss, the right to own the profit is secured;" "The consideration for which an employer guarantees the wages of labor is the expected profit;" "The consideration for which a man accepts wages is the means of present support and immunity from risk of loss," are a few of the doctrines which are worthy of being carefully kept in mind by all classes.

Der Brückenbau. *Ein Handbuch zum Gebrauche beim Entwerfen von Brücken in Eisen, Holz und Stein, sowie beim Unterrichte an Technischen Lehranstalten.* (Bridge Construction: A Manual for use in Designing Iron, Wooden, and Stone Bridges, and also for Instruction in Technical Schools.) By E. Häseler, Professor in the Technical High School at Brunswick. Volume I, Parts I and II. Octavo, paper, 239 pp., and 37 plates. Brunswick: F. Vieweg & Son, 1888 and 1893.

This work is to consist of three volumes, the first on iron, the second on wooden, and the third on stone bridges. It is not stated whether or not the two parts before us constitute the whole of the first volume, but with the exception of joints and lateral bracings they cover the subject of common truss bridges in a fairly complete manner. The six chapters treat of the following topics: General Arrangement and Main Parts of Trusses, Quality of Material and Allowable Stresses, Rivets and Bolts, Cross-sections for Chords and Webbing, Bed-plates and Rollers, Roadway and Sidewalks. In Part I the presentation may be called descriptive and practical, although the theoretical and empirical formulas for obtaining dimensions are usually given. The chapter on the roadway and floor system, however, contains lengthy theoretical investigations regarding the flexure of buckle and corrugated plates. It was in order to perfect these investigations that the publication of Part II was delayed so long as five years after that of Part I. The efforts of the author during this period to deduce satisfactory formulas for buckle plates have not been rewarded with success, on account, he says, of the imperfect state of the science of the strength of materials. Nothing but comprehensive tests will enable this to be done, and such tests must be mainly made within the elastic limit of the material.

The author takes account of shocks and dynamic stresses by using the formulas of Weyrauch and Launhardt, which are based on Wöhler's experiments. For columns Rankine's formula is used, but no comparison is made with the results of tests, and the list of literature given includes none of the many investigations conducted in this country. The chapter on cross-sections for chords and web members, which consists of only 16 pages, might have been greatly extended; eye-bars, indeed, are scarcely considered at all. Bed-plates, rollers and rockers, on the other hand, are given 40 pages, the theoretical discussions predominating. The chapter on roadway systems occupies the whole of Part II (110 pages), and it contains, besides the theoretical investigations already mentioned, many practical details which might advantageously be studied in this country. The weak point in American bridges, as is generally known, is the floor system, and anything which tends toward its improvement is gladly welcomed.

The work of Professor Häseler is probably of that compendious kind, so common in Germany, which requires years in publication, the first parts perhaps passing through several editions before the last ones are issued. The 37 plates of the two parts before us contain 321 cuts of bridge details, all beautifully drawn and every line having its meaning, many of which are likely to be of value to American designers, since the methods of bridge construction on the two sides of the Atlantic are likely to become more and more similar as the prices of iron and labor become more nearly equal.

A Practical Treatise on Foundations. *Explaining fully the Principles Involved, with Descriptions of all the most recent Structures, Accompanied by numerous Drawings; also an Accurate Record of the Bearing Resistances of Materials as Determined from the Loads of Actual Structures.* By W. M. Patton, C.E. New York: John Wiley & Sons. (402 pp., 6 in. × 9 in.)

The author of this book, who has had over 18 years of active practice in the construction, and has been a professor of engineering for 6 years, begins his treatise by telling his readers that "in a work on foundations, theories and formulæ are of little value; and therefore but little space is given to the discussion or criticism of either." In the discussion of the theory of arches he says, in confirmation of the view expressed in his preface, that it "is perhaps as little understood as in ages past. Mathematical and mechanical theories, after carrying you through the intricate mazes of higher mathematics, have surely led to no satisfactory or practical results. . . . Mr. Rankine, after going through a most able and wonderfully conceived discussion of this subject, tells you to make your factor-of-safety from 20 to 40, and closes by saying: 'The best course in practice is to assume a depth for the keystone according to an empirical rule, founded on dimensions of good existing examples of bridges.'" This recalls the master mechanic's rule for calculating the counter-weights of a locomotive, "Figger awhile, and then guess at it."

Undoubtedly the value of mathematical calculations is very limited in the design and construction of foundations. The data on which such calculations are based are always uncertain. The author of the book before us has therefore done well to treat his subject almost entirely in an empirical method. His inferences are drawn from experience, and he tells his readers whether the results were satisfactory or otherwise.

The various chapters or articles, as they are called, are on Foundation Beds, Foundations, Concrete, Building Stones, Quarrying, Stereotomy, Masonry, String Courses and Coping, Ice and Wind Pressures, Retaining Walls, Arches, Brick, Box Culverts, Cements and Hydraulic Limes, Mortar, Sand, Stability of Piers, Waterway in Culverts, Arch Culverts, Cost of Work, Definitions and Tables, Timber Foundations, Coffer Dams of Timber, Open Caissons, Cushing Cylinder Piers, Sounding and Borings, Timber Piers, Framed Trestles, Properties of Timber, Durability of Timber, Preservation of Timber, Joints and Fastenings, Trestle Foundations, Timber Piles, Comparative Estimates of Costs of Framed and Pile Trestles, Embankment of Earth on Swamps, Deep and Difficult Foundations, Pneumatic Caissons, Caisson Sinking, Combined Crib and Caisson, All-Iron Piers, Location of Piers, Poetch Freezing Process, Quicksands, Foundations for High Buildings, High Buildings.

All these subjects are treated in a discursive sort of way, the author bringing together a large amount of his own and other engineers' experience in the construction of foundations. Excepting in the discussion of the Theory of Arches, but very little mathematical elucidation is employed. The illustrations are nearly all contained in 23 folded plates at the back end of the book. The defect of these is that their scale is too small. Apparently the drawings were reduced so that they would go on a page of the book. The folded sheets afford ample space for larger illustrations, which would be more satisfactory. A more liberal use of engravings all through the book would, we think, have added to its value. Take as an example the article with the title "Definitions," which contains explanations of the meaning of such terms as skew-back, arch-ring, intrados or soffit, etc. A well-executed illustration showing these parts and their relation to others would have made the whole matter much clearer to the reader, and would have impressed the matter on his mind much more ineffaceably than a mere verbal definition can. From the book it may be inferred that the author, like many other civil engineers, is not a draftsman, and does not think graphically. Altogether it is an excellent book, and has the great merit of lucidity. It is very clearly written, easily understood and practical throughout, and the best book in the language for the student of the subject to which it relates or for a young engineer engaged in that kind of work.

Locomotive Running Repairs. By L. C. Hitchcock, General Foreman of "Soo Line" Shops. Terre Haute, Ind.: Debs Publishing Company. (108 pp., 4 × 6 in.)

In this little book the author says that it has been his desire "to give," in language as concise as possible, some methods of making running repairs on locomotives, which, from personal observation, he knows to have been productive of good results," and that "the book is more especially calculated to benefit machinist apprentices and those inexperienced in this class of work."

The writer, it is thought, has succeeded admirably in his purpose. It is clearly written and well illustrated, and all the instructions are expressed in language which any apprentice ought to be able to understand. In the different chapters the following subjects are discussed: Grinding in Brass Valves, Cocks, etc.; Rods, Setting up Wedges, Tramming; Springs; Setting Slide Valves; Flange Wear; Shoes and Wedges; Driving Boxes; Washing Boilers; Moving Eccentrics; Back Cylinder Head; Guides; Tire Wear; A Time-Saving Wheel Truck; A Signal Holder.

The author discusses a range of subjects which do not often receive consideration in other books on the locomotive. He explains methods and appliances for doing work, and gives diagrams to show how to proceed, and has that comparatively rare faculty of understanding his subject thoroughly and then of placing himself in the attitude of mind to it which a person who does not understand it must occupy. He does not waste phrases in talking twaddle, but goes directly at his subject, with the evident purpose of inserting his own idea into the head of the fellow he is writing for. Unless that fellow is a blockhead, Mr. Hitchcock will undoubtedly succeed in what he aims to do.

His book is well printed on good paper with limp covers, and is designed to be carried in the pocket. It ought to have a place in the pocket of every apprentice and most of the journeymen in every locomotive shop in the land and out of it.

One adverse criticism we feel bound to make. The book is bound with wire, and the back is held together as though it had been riveted in a hydraulic riveting machine. The inside margin on the pages is narrow, so that they are not easily read. If in another edition the publisher would move the type outward ¼ in., so as to narrow the outside margin that much and widen the inside one, it would be a great improvement.

Manual of Irrigation Engineering. By Herbert M. Wilson, C.E. New York: John Wiley & Sons. (351 pp., 5¾ × 9 in.)

This book is intended for irrigation engineers and not for irrigation farmers. It is divided into three parts, which treat of Hydrography, Canal and Canal Works, and Storage Reservoirs. It is illustrated by 29 full-page plates and 100 smaller engravings. The subject is discussed very fully—sometimes it is thought too much so. The author often runs into platitudes and fatuitous observations which are exasperating. Thus, in speaking of the "relation between lands and water supply," the reader is gravely informed that "in designing an irrigation work the first consideration is the land to be irrigated." In speaking of "survey and alignment" it is said: "Having determined the source of water supply and its relation to the irrigable lands, the third question in order of importance is the alignment of the canal;" and again, "In order that the best possible alignment may be obtained, careful preliminary and location surveys are necessary;" and on "obstacles to alignment" it is thought necessary to tell irrigation engineers that "such obstacles as streams, gullies, ravines, unfavorable or low-lying soil or rocky barriers, are frequently encountered in canal alignment." On "curvature" the grave observation is made that "a direct or straight course is the most economical." The writer might as well have added a demonstration that the shortest distance between two points is a straight line.

The book is, however, full of useful information mixed with a good deal of chaff, and will be interesting and useful to all who are concerned with the subject of which it treats and which is of rapidly increasing importance.

BOOKS RECEIVED.

The Rensselaer Polytechnic Institute Handbook of Information. Troy, N. Y.

The Transition Curve by Offsets and by Deflection Angles. By C. L. Crandall, C.E. New York: John Wiley & Sons.

The First Steam Screw Propeller Boats to Navigate the Waters of any Country. By Francis B. Stevens. Reprint from the Stevens *Indicator.*

Objects of Interest to Engineers and Others in and about Philadelphia. Presented with the compliments of the Engineers' Club of Philadelphia.

World's Columbian Exposition at Chicago. The United States of Venezuela in 1893. Published by order of the Government of Venezuela. New York.

Tables for the Computation of Railway and Other Earthwork. Computed by C. L. Crandall, C E. Second Edition. New York: John Wiley & Sons.

Transactions of the Liverpool Engineering Society. Vol. XIV. Edited by R. C. F. Annett, Honorary Secretary. Liverpool: Published by the Society.

British Railways: Their Passenger Services, Rolling Stock, Locomotives, Gradients and Express Speeds. B. J. Pearson Pattison. London: Cassell & Co., Limited.

Proceedings of a National Convention of Railroad Commissioners, held at the office of the Interstate Commerce Commission, Washington, D. C., April 19, 20, 1893.

Addresses Delivered before the World's Railway Commerce Congress. Held in Chicago, Ill., June 19–28, 1893. Chicago: *The Railway Age and Northwestern Railroader.*

Compound Locomotives. By Arthur Tannatt Woods. Second Edition, Revised and Enlarged by David Leonard Barnes. Chicago: *The Railway Age and Northwestern Railroader.*

Interstate Commerce Commission's Fourth Annual Report of the Statistics of Railways of the United States. Washington: Government Printing Office. (655 pp., 5¾ in. × 9 in.)

Continuous-Current Dynamos and Motors, their Theory, Design and Testing. An Elementary Treatise for Students. By Frank P. Cox. New York: The W. P. Johnston Co., Limited.

The Science of Mechanics. A Critical and Historical Exposition of its Principles. By Dr. Ernst Mack. Translated by Thomas J. McCormack. Chicago: The Open Court Publishing Company.

Fifth Special Report of the Commissioner of Labor. The Gothenburg System of Liquor Traffic. Prepared under the direction of Carroll D. Wright, Commissioner of Labor. By E. R. L. Gould. Washington: Government Printing Office.

TRADE CATALOGUES.

HOW TO SELECT DRAWING INSTRUMENTS, Keuffel & Esser Company, 127 Fulton Street, New York. This is a small pamphlet of 12 pages (5¾ × 8¾ in.), whose purpose is indicated by its title. It is illustrated by engravings of various kinds of instruments sold by this Company, and contains many hints to draftsmen about the choice of instruments.

MESSRS. A. WHITNEY & SONS, of Philadelphia, manufacturers of car wheels, have republished the circular of inquiry of the Committee on Cast Iron Wheels appointed by the Master Car-Builders' Association, with their own reply to the inquiries and the report of the Committee. The significance of the publication is the bearing it has on the advantages of a contracting chill in making cast-iron wheels.

THE SIEMENS & HALSKE ELECTRIC COMPANY of America, whose headquarters are in Chicago, have issued a pamphlet describing different applications of electric motors to the operation of machinery under the patent granted to Carl Hofman and Ernest Richter, of which the above Company are the assignees. The pamphlet is intended to explain the application of the inventions covered by this patent, and the Company announce that they will issue licenses to use the invention for a nominal consideration.

THE BERLIN BRIDGE COMPANY have issued a very neat little "folder" announcing that their new catalogue of over 300 pages, illustrating and describing iron buildings for machine shops, foundries, rolling mills, casting shops, electric light and power plants, is now ready for distribution. The expense of this catalogue is so great, they say, that they cannot afford to send it broadcast, but to persons who are interested in this class of work they will take pleasure in mailing a copy if they so desire.

THE BENNETT MANUFACTURING COMPANY, 1510 Chestnut Street, Philadelphia. This Company, which is engaged in the manufacture of Engineers', Draftsmen's, and Architects' Instruments and Supplies, in the preface to the volume before us speak of it as their "introductory catalogue." It contains 24 pages (5¼ × 8¾ in.) which contain some very excellent engravings of the instruments made by them. In the preface they say:

"The adaptation of aluminum in the manufacture of scientific instruments is original with us, and we are at present the sole producers of such goods, having exclusive advantages in regard to the treatment and use of this comparatively new and wonderful metal which other houses have not been able to attain. Instruments made of aluminum are cleaner and lighter and quite as substantial as German silver, besides possessing the added advantage of being non-corrosive."

We have had the privilege of handling some of these instruments, and they certainly have the merit of being much lighter than those made of German silver. Some novelties are illustrated in the catalogue, among them what is called a duplex pen for drawing heavy and light lines at will, which commends itself at sight to an experienced draftsman.

CRANES AND SPECIAL RAILWAY APPLIANCES, as Designed and Built by the Industrial Works, Bay City, Mich., 107 pp., 6¾ × 10½ in. This book is another excellent example of the kind of literature of which our manufacturers are now so prolific. It is illustrated with the usual half-tone prints, the first two being interior views of their works. These are followed by illustrations and descriptions of a traveling crane in the Chicago, Milwaukee & St. Paul Railway shops, a walking jib crane, a pillar crane for yard work, a transfer crane for freight yards or stations, a 35-ton steam-wrecking crane mounted on a car, double wrecking cranes mounted on a long car, a 20 ton construction and yard crane, a locomotive crane, a steam railway crane, a double hand-wrecking crane mounted on a car.

In the second division of the book various hints of excavation pile drivers, transfer tables, portable steel rail saws are described. The book is an indication of the extent to which cranes are being employed in this country. Their manufacture is a comparatively new industry, which is or was growing very rapidly. If this company could only equip the Senate chamber in Washington with an overhead crane with sufficient capacity to lift the members out of the slough into which they have fallen, the business of crane making would probably improve.

GOULD COUPLER COMPANY. Malleable Iron Works, Depew, N. Y., Steam Forge, Buffalo, N. Y. The catalogue of this Company is a volume of 47 pages, 9 × 12 in. It is elaborately illustrated with "half-tone" and "wax-process" engravings, and is printed on heavy coated paper, in large type, with wide margins. The frontispiece is a bird's-eye view of the new Malleable Iron Works at Depew, which is apparently made from a very good wash drawing. This is followed by views of the Steam Forge of the Company, made from photographs. A brief description of these two establishments follows, giving their location, size, etc. The next engraving is an end view of a freight car equipped with the coupler which this company manufactures. Four full-page engravings show the detached details which are all numbered and their names given in a printed list opposite. On one page the parts are shown in outline, and their dimensions are given. A full-page perspective view and outline drawings of the details of a tender coupler are shown.

Similar views and descriptions are also given of the Gould Pendulum Vestibule and the company's Buffer and Continuous Platform.

The latter part of the book contains interior views of the Forge, showing a steam and trip hammer and their products, consisting of axles, links and pins, etc.

BUCYRUS STEAM SHOVEL AND DREDGE COMPANY, South Milwaukee, Wis. Catalogue Part I, Steam Shovels; Parts II and III, Dredging and Excavating Machinery.

These books are also 9 × 12 in., the first having 43 and the latter about twice that number of pages, which are not numbered. In the first the works and their location are described. Seven different forms and sizes of steam shovels mounted on railroad cars are illustrated by perspective views made from photographs, and by outline engravings made from drawings. The construction of these is described in the preliminary pages. There is then a very good view of a Fox pressed steel truck, and outline engravings of what is called a "land dredge" mounted on wheels suited to run on a temporary track. Accounts of the capacity, range of work, and material in which it can be advantageously used completes the volume.

The II and III parts of this Company's catalogue are illustrated by similar illustrations to those which have been described. There are eight full-page views of different kinds of dipper dredges—that is, dredges which consist of a dipper or bucket operated from the end of a boom. Four views of hoisting engines are shown, one of a steam cylinder for operating hoisting frictions of dipper dredge, and another interior view of a dredge showing the boiler engines and hoisting machinery. The succeeding part of the book contains 10 very interesting views made from photographs of dredges which have a series of buckets operated by an endless belt or chain. Several pages of details of these machines complete the volume.

The criticism which we feel inclined to make of these publications is that they do not contain enough descriptive matter. A novice naturally looks to a book of this kind for information on the subject to which it relates. It seems as though such a book ought to contain an elementary treatise on dredging, showing and explaining what kind and quantity of work can and cannot be done by such machines, where and how they can be used to advantage, the principles of their construction, their weak and strong points, what those using such machines should do and what they should avoid, and although this need hardly be pointed out, the peculiar points of excellence of the machines illustrated. Such a treatise would be of permanent

value to those interested in them, and probably no one is more competent to give such information than the makers of these machines.

The same Company also send a smaller pamphlet, which describes the machinery they make for placer mining, which is somewhat out of our line. The books are all well illustrated, well printed on good paper, and give an excellent idea of the general character of the appliances manufactured by this Company.

THE DODGE MANUFACTURING COMPANY, of Mishawaka, Ind., have published what they call a Souvenir Pamphlet of the World's Columbian Exposition. The striking feature at the first glance is the beautiful color, texture, and typography of the cover. The paper has a rough surface, the title being printed in fancy type in dark green ink of some kind which has a glossy surface.

The pamphlet gives a history of this establishment, which was started in 1878 for the manufacture of "wood hardware." In 1881 the works were destroyed by fire, and as stated, "certain pulleys were constructed of wood and with the bushing system, which proved so satisfactory that it was decided to make wood pulleys the main feature of manufacture. The difficulties in the production of wooden pulleys capable of competing with iron pulleys in other respects were not overcome until the ingenuity and skill in this Company produced the Independence Patent Pulley. One of its principal features is the system of interchangeable bushings, whereby any pulley may be fitted to a shaft of any diameter."

At present this Company do an immense business, and have over 600,000 of them in use. The business has developed to a tremendous proportion, and is now a distinct branch of American mechanical engineering.

Besides wooden pulleys this Company also manufacture a patent system of power transmission by manilla rope, a full line of mill and factory furnishings, such as drop hangers, post hangers, pillow blocks, floor stands, friction clutches, etc., all from new designs and patterns.

Among the illustrations in the book is a view of the interior of the engine-room of the works, which is said to be "one of the finest engine-rooms in the United States, if not in the world," and the statement is entirely credible. The walls, ceiling, and floor are elaborately decorated, a highly ornamental fireplace and a desk give an air of comfort and convenience which would not be expected in such a place. An American eagle surmounts the mantel and inspires patriotic feelings.

The description of this establishment shows us another instance of how "tall oaks from little acorns grow" in this country.

THE EVOLUTION OF ARTIFICIAL LIGHT. From a Pine Knot to the Pintsch Light. Compliments of the Passenger Department Union Pacific System, Omaha, Neb., 109 pp., 5 × 7¾ in. At first sight the purpose of this luxuriously printed book is not apparent. It is bound on the short side, and is thus what may be called a dwarf volume. The cover is rough white paper, with the title printed in colors and gold, and altogether is very attractive. The titles are respectively, Light of Other Days; House Light; Torches and Lamps; Candles, Lanterns and Links; Oil Light; Gas Light; Street Lights; Beacon Lights; The Electric Light; The Pintsch Light; Railway Car Lighting. In these the history of the various kinds of lighting is given in considerable detail, and many interesting facts are related. The purpose of the book is skillfully interwoven into the last chapter, in which the method of lighting the Union Pacific cars with the Pintsch light is described, which description is succeeded by the statement that "this great national highway is so well known," etc. Then follows a description of the line, its attractions, advantages, etc. There is a map of the line, a view of the mammoth natural gas well near Salt Lake City, another of a young lady "on the beach at Garfield," who is displaying her nether limbs rather promiscuously; a scene near Leadville, Col.; another of the loops above Georgetown; one of Platte Cañon; the Ames monument at Sherman, Wyo.; the great Shoshone Falls, Ida.; Cloud Cap Inn, on summit of Mt. Hood; Mt. Hood itself; Echo Canon, Utah; Witch Rocks, Echo Canon, Utah; Pulpit Terraces, in the Yellowstone National Park, which completes the illustrations.

The book is a probable forerunner of a kind of composite literature in which advertisements of our leading lines of railroad will be interwoven with all kinds of interesting reading matter. We may have a railroad novel in which the characters will be skillfully made to speak words of commendation for the great Cross Cut line. We may have poetry whose meter will accord with the rattle of rail joints and resound with praise of the latitudinal road, or a tragedy which may culminate in a railroad accident on the competing line, with the principal characters appearing in the last act in various conditions of dismemberment, and expressing remorse that they did not take the Interpolar route, and wildly imploring every one else to do the same thing There is no telling what the authors of this kind of literature may have in store for us.

SANDY SKIRLED AWA' AND DROWNED THE ELECTRICAL PIANO.

THE Chicago *Herald* of some weeks ago contained an account of an interesting episode which gave variety to the monotony from which the exhibitors suffered at times in the Transportation Building of the great show in Chicago. Back of the model of the village of Pullman, in this building, were the exhibits of three manufacturers of car seats. One was a Philadelphia establishment, the next came from St. Louis, and the third was from a Chicago house, which was presided over by a gentleman with a military title and character, and "whose sunny disposition," the *Herald* says, "is announced in a smiling face and a full waistcoat." The Philadelphia exhibit was presided over by an enterprising young gentleman who is very zealous in the interest of his employers. As we cannot hope to emulate the graphic style of the *Herald's* reporter, in describing the episode referred to, we quote from him, with some omissions of names, etc.

The *Herald* says things were getting dull in Transportation Building when the young gentleman in charge of the Philadelphia seats conceived the brilliant idea of attracting attention to his exhibit by providing music in his booth. The music had to be cheap, noisy, and continuous to suit his idea, and he considered that he had struck the very thing when he leased a piano that is run by electricity. So it came about that one morning last week the ears of all the exhibitors within hailing distance of the booth in charge of the enterprising young gentleman were assailed by the strident notes of "Maggy Murphy's Home," followed by "Down Went McGinty," and similar choice selections.

A troubled look came over the genial countenance of our martial friend when the electrical nuisance broke forth in melody. The rotund representative of the Chicago patent reversible chair-car seat leaned back in one of them, thrust his fingers into his ears and puckered his brows in thought. Suddenly his expression changed; he sprang to his feet, slapped his leg, and said to himself, "I'll do it."

In a trice he was hurrying to the terminal station, and the first north-bound Illinois Central express train carried him to the city, leaving the young Philadelphian and his piano surrounded by an admiring crowd, in undisputed possession of the field. The man of war presently reappeared in the Transportation Building. By his side strode a big, raw-boned Scotchman. The man from the land of Bobby Burns was clad in a kilt and wore a Tam o' Shanter, a big green plaid tartan, and over his shoulder he carried a set of Scottish bagpipes.

Our friend from the Quaker City was at lunch when the Scotchman appeared on the scene, and the electrical piano was silent. The Commander-in-Chief of the Chicago exhibit in the mean while deployed the man with the bare legs and the bagpipes up in the end of his booth near his rival's exhibit, and after some whispered instructions retreated to his desk, chuckling to himself meanwhile.

Soon after 1 o'clock the Philadelphian hurried into his booth, grinned at his friend across the way, and turned loose the piano. The General sprang to his feet, as the first offensive notes floated out on the hot afternoon air, and shouted, "Skirl awa', Sandy."

The big piper started "The Campbells are Coming." High above the brassy rattle of the piano sounded the wailing notes of the bagpipes. The Quaker music was completely drowned out. The crowd that had been pressing about the Philadelphia booth turned to the new attraction and forgot the old. Back in the corner our military friend laughed so immoderately that his face was the color of the crimson plush seat on which he sat. All the afternoon the fun was kept up. Whenever the piano began to tinkle the piper began to blow. The following morning "Sandy" was reinforced by one of his countrymen, and all day long the man of war and the Scotchman had fun with their friend and his automatic music box.

The space about the Chicago exhibit was packed with people, but it would be difficult to say whether they were most amused at the pipers or the little fat man who held his sides and

laughed till the tears ran down his face every time a new tune was struck up.

While all this was going on the philosopher from the banks of the Mississippi, in charge of the St. Louis exhibit, was engaged in sage elucidation of the superiority of the Scarritt seats to admiring crowds, and showed conclusively that the chariot which carried Elijah up into heaven by a whirlwind was provided with one of them, with a flexible back and adjustable foot-rests; and when the Philadelphian heard of it, it is said that "he took hold of his own clothes and rent them in two pieces."

NOTES AND NEWS.

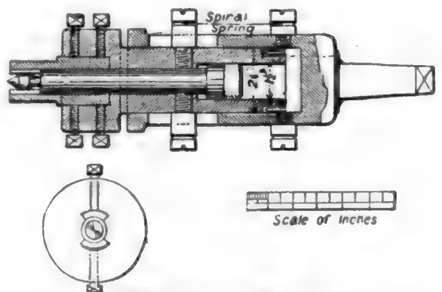
A New Explosive.—A commission of German artillery experts have been testing a new explosive with which it is proposed to replace gunpowder in the German army. The explosive is a brown fatty substance of the consistency of frozen oil when exposed in ordinary temperatures. It retains this consistency up to 112° F. A shock or a spark does not set it off. When used in guns, the explosion is obtained through contact with another chemical compound. The explosion is almost unaccompanied by smoke, and the detonation is inconsiderable. The recoil is very slight, even when the heaviest charge has been used. The explosive does not heat the weapon sufficiently to cause difficulties in the way of rapid firing, and cartridges once used are easily refilled.

For the present rifle the new compound is not available, but if future tests be as satisfactory as the recent ones, it will be introduced generally in the artillery branch of the service.

Railroads in Newfoundland.—At present there is a railway, 84 miles long, from St. John's to Harbor Grace, with a branch line of 25 miles connecting with Placentia. Another railway has been in the course of construction for over two years toward the Exploits River and on to Hall's Bay, thus going northward through the center of the island. About 140 miles of the railway are said to be completed, and the whole is expected to be laid down by the end of 1894. The new contract is for a railway of 250 miles to connect these railways with the west coast by way of the Bay of Islands, St. George's Bay, and Port Basque Bay, in the southwest corner. Thus the main part of the island, leaving out the long northern peninsula, will within a very few years be covered with a net work of railways, which will leave no excuse for the non-development of the resources of the interior. That interior is in many parts almost unexplored, though it is believed to contain mineral and timber resources of which much could be made. What are the agricultural capabilities of the interior remain to be seen. Over the internal resources of the colony no foreign nation has any lien; and the unrestricted development of these cannot but place Newfoundland in a condition of prosperity, which she has never yet attained. The contractors for the new line, who are also to work for 10 years the Hall's Bay and Placentia Line, seem to have made a very good bargain for themselves. In addition to the cost of construction, they are to receive two and one-half million acres of land, with the mineral and timber rights upon it, along the new line, and a subsidy of $36,000 per annum for the carriage of the mails. If they set to work in earnest in the development of their extensive property the result cannot but be for the benefit of the colony at large.—*The London Times.*

A Steam Artillery Wagon.—M. Serpollet, who in 1888 brought out his instantaneous steam boiler, has since then adapted it to a variety of vehicles, including the cycle, phaeton, omnibus, and now, at length, the artillery wagon. The French artillery wagon is very large, and contains a load of 1,500 kilogrammes. Moreover, it should attain a speed of eight kilometers an hour, and be able to run for 40 kilometers without a halt A second wagon is sometimes taken in tow with a load of 3,000 kilogrammes, and in this case the speed ought to be about four kilometers an hour on the average. M. Serpollet had also to fit the new motive power to the existing wagons. His motor is capable of supplying 40 H.P., and the boiler can support a pressure of 25 atmospheres. The power applied to the wagon can be quickly increased to meet obstructions and other difficulties of the road, thus imitating the action of horses. The motor is fixed under the rear of the wagon, and actuates the hind wheels by means of chains. The weight is balanced by the generator, which is placed in the front of the wagon, where the proper controlling apparatus is also situated under the hands of the driver. Inclines of 18 in 100 have been successfully surmounted by the wagon in several trial runs of 40 kilometers, and the expenditure of coal at a speed of 14 kilometers an hour was 2.5 kilogrammes per kilometer, while the consumption of water was 13 kilogrammes for the whole run. The weight of the vehicle and its load was 4,300 kilogrammes. The cost is therefore estimated at one-third of the expense of horse traction, and the steam wagon has this advantage, that it requires no rest, provided the supply of fuel and water is kept up. It is probable that many omnibuses and other heavy vehicles in France will now be propelled on the Serpollet system.

Tube-plate Boring-tool.—The accompanying illustration represents a tool which was patented several years ago. We have seen it in operation on the continent, and can answer for the excellence of the work done by it. The construction will be clearly understood from the cut. In an outer casing, provided at the top with a shank for insertion in an ordinary drill chuck, is a circular annular piston, having at its lower end the tool holder. In this annular piston works a second small piston with a stout piston-rod terminating in a hard steel center. The space above the two pistons is filled with thick oil. The area of the annular piston is 2.2 sq. in., that of the smaller piston 1.8 sq. in.



A TUBE-PLATE BORING TOOL.

The tool is mounted as a drill in any suitable drilling machine. The centers of the holes to be bored are marked deeply with a center punch. The tool is lowered in the ordinary way by the mechanism of the machine till the center presses firmly into one of the punch marks. As the pressure is increased it is evident that the external annular piston descends, forcing the tool against the plate. The tool revolves and the hole is cut, and as the center is always firmly pressed against the plate, the tool turns without any "wobble" or "dither," and the hole is cut perfectly true. On releasing the pressure the spiral springs at the sides draw the tool back to its normal position. The two lower studs to which the springs are attached pass through slots in the outer casing, and the end of one of them projects into a keyway cut in the piston-rod, so that all three parts rotate together. The tool and tool-holder are of very simple construction, and will be readily understood from the cut.

The Rifle Trenching-tool.—A correspondent of the London *Times* writes to that paper: "Attempts have often been made to supersede the independent trenching-tool at present in use in the army by one in which the soldier's rifle should be employed as the stock or handle. In these attempts the spade portion has generally been connected up with the barrel of the rifle, which method is open to objection. A new system, in which the trenching-tool is connected to the butt-end of the rifle, has been invented by Captain Léon de Layen, a French military officer who has seen some service, and was recently tried on the parade-ground of the Honorable Artillery Company at Finsbury. The tool consists of a steel spade having a short square shaft or handle formed upon it, the tool being carried in a leather case on the soldier's breast. To the stock of the rifle is attached a steel socket in which the tool is fixed when wanted for use, being firmly held by a spring catch and released by the pressure of the thumb. Equipped with this tool Captain de Layen went through trenching and various other drills, and demonstrated that the tool in no way interfered with the drills, subject to one or two slight alterations in them. It was shown that bayonet drill and firing were also easily performed, while, if the men were surprised at close quarters during trenching work, the spade attached to the butt of the rifle made a ready weapon in place of the bayonet. The equipment and rifle were then transferred to an assistant, who was given 10 minutes to intrench himself. In five minutes, in the opinion of some military officers present who had

seen service, he had thrown up a good shelter, and by the end of the 10 minutes had well intrenched himself. A squad then opened fire upon him, and he replied with the trenching-tool still fixed. The firing party then advanced and he retired a given distance, firing on the way, and when the marked point was reached he commenced to throw up another shelter, which he sufficiently completed in two minutes, and he then recommenced firing on the enemy. The opinion of the officers present was that it was an efficient tool, and that in use it was not in any way calculated to injure the rifle, which, in working, is gripped by the breech-end of the barrel and the throat of the stock. The leading idea is that every infantry soldier should become a sapper and miner or an engineer."

On the Life of Iron Bridges.—The following letter has lately been addressed to a member of the Glasgow Town Council by Sir William Arrol: "I am in receipt of yours of the 4th inst., and in reply have to say that if the convener is under the impression that the life of an iron bridge is only 40 years, he is under a mistake, as the life of an iron bridge depends entirely on how it is kept and the material with which it is painted for its preservation. I may say that in my experience I have examined a considerable number of iron bridges, and one I examined was up for 50 years, and the parts of it which were properly looked after were practically as good as on the day they left the works. Some three months ago I examined another brid e over a river; it had been up 30 years, and had not been painted for 15 years, but there was very little corrosion, the parts that were rusted were parts where drips of water had fallen and had not been properly attended to. Then, again, I examined another a few weeks ago which has been up 38 years, and every part of that bridge is practically as good as on the day it was put up. A few years ago I bought the material of the old Hammersmith Bridge, London, for the purpose of using it as a temporary plant in the erection of the Forth Bridge. It had been up for 62 years, and a great many of the parts had not been painted since its erection, as it was impossible to get at them; yet these parts were in a good state of preservation—in fact, quite as good as when they left the works. I took some of the material with which it had been painted to ascertain the reason for the good state of preservation it was in, and the result of the analysis was that the material with which it had been painted was genuine white lead. You can see from these samples that an iron bridge, properly taken care of by those responsible for it, will last practically for any length of time. The Bonar Bridge, which we have just replaced, was carried away by the strong floods; it had been up for 80 years. The iron part of the bridge, which was 150 ft. span, was perfectly good, but the masonry piers got scoured out and washed away, therefore the iron work fell into the bed of the river and was destroyed."

Speaking at the Engineering Congress at the World's Fair, Sir Benjamin Baker stated that in examining old wrought-iron bridges he had found that the bridges had suffered most at the joints, and not at places where the strain sheets would show the greatest fatigue. In the case of bridges having trough floors, for example, he had found that the failures were serious where the flooring was connected to the webs of the main girders. He had seen the web-plates nearly cut through with the wriggling of the connections, and considered it to be better practice to put the troughs directly on top of the angle plates. In other riveted parts he had found the greatest wear from the loosening of the rivets.

The Phonograph as a Cure for Deafness.—Dr. George A. Leech recently delivered a lecture at the Leech Institute, 39 West Twenty-seventh Street, New York, on a new method of curing deafness by means of the Edison-Leech phonograph. Illustrations were given of his method of treating deaf patients by introducing into the ear a vibratory piece of an intensity sufficient to cause even deaf-mutes to hear. The New York *Times* gives the following report of this lecture:

"I regard the Edison phonograph as the most wonderful invention of an age remarkable for its great discoveries. It is the human voice and the human ear rolled into one.

"But it was not designed as an instrument for the cure of deafness until I invented and applied to it certain apparatus which makes it complete for that purpose. In order to hear, it is absolutely necessary that three little bones called the hammer, anvil, and stirrup, situated in a little cavity known as the drum or middle ear, should be made to vibrate at a certain rate of speed."

After explaining how these bones were connected, and the manner in which sound was conveyed to the auditory nerve and brain, he said: "The speed with which these bones move varies from 16 to 30,000 times in a second. Vibrations slower than 16 times a second are not fast enough to be recognized as sound by the human ear, while those exceeding 30,000 vibrations are so rapid as to be beyond its capacity for hearing.

"A person is deaf when the joints of these bones become stiff and do not respond properly to the vibrations of sound, and the degree of deafness is measured by the amount of stiffness in these joints.

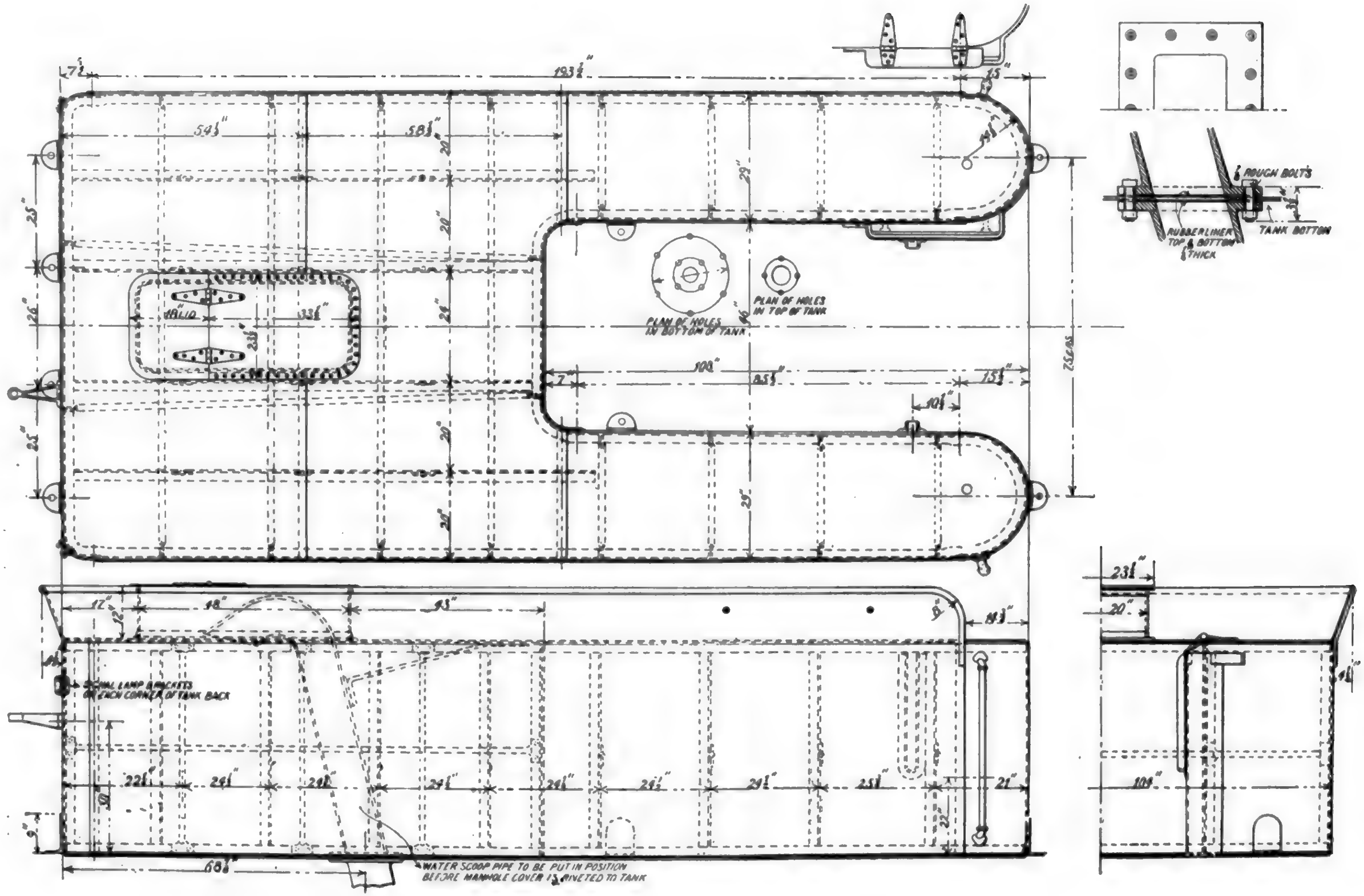
"The reason why most deaf people hear better in a noise, such as the rumbling of street cars, is because the extraordinary loud sounds falling on the ear compel the bones in the drum of the ear to vibrate with the required speed to convey sounds to the brain. In this fact lies one of the secrets of the method employed for the cure of deafness. We apply in a scientific way, by means of the improved phonograph, vibrations of sufficient intensity to move the delicate mechanism of the human ear. In this way we render the joints in the drum of the ear movable.

"The principle of treatment employed is the massage, or mechanical stimulation, and the consequent reawakening of the sound-conducting apparatus of the ear, by means of vibrating force. The character, frequency, and intensity of the vibrations are regulated by the surgeon, according to the exigencies of the case under treatment."

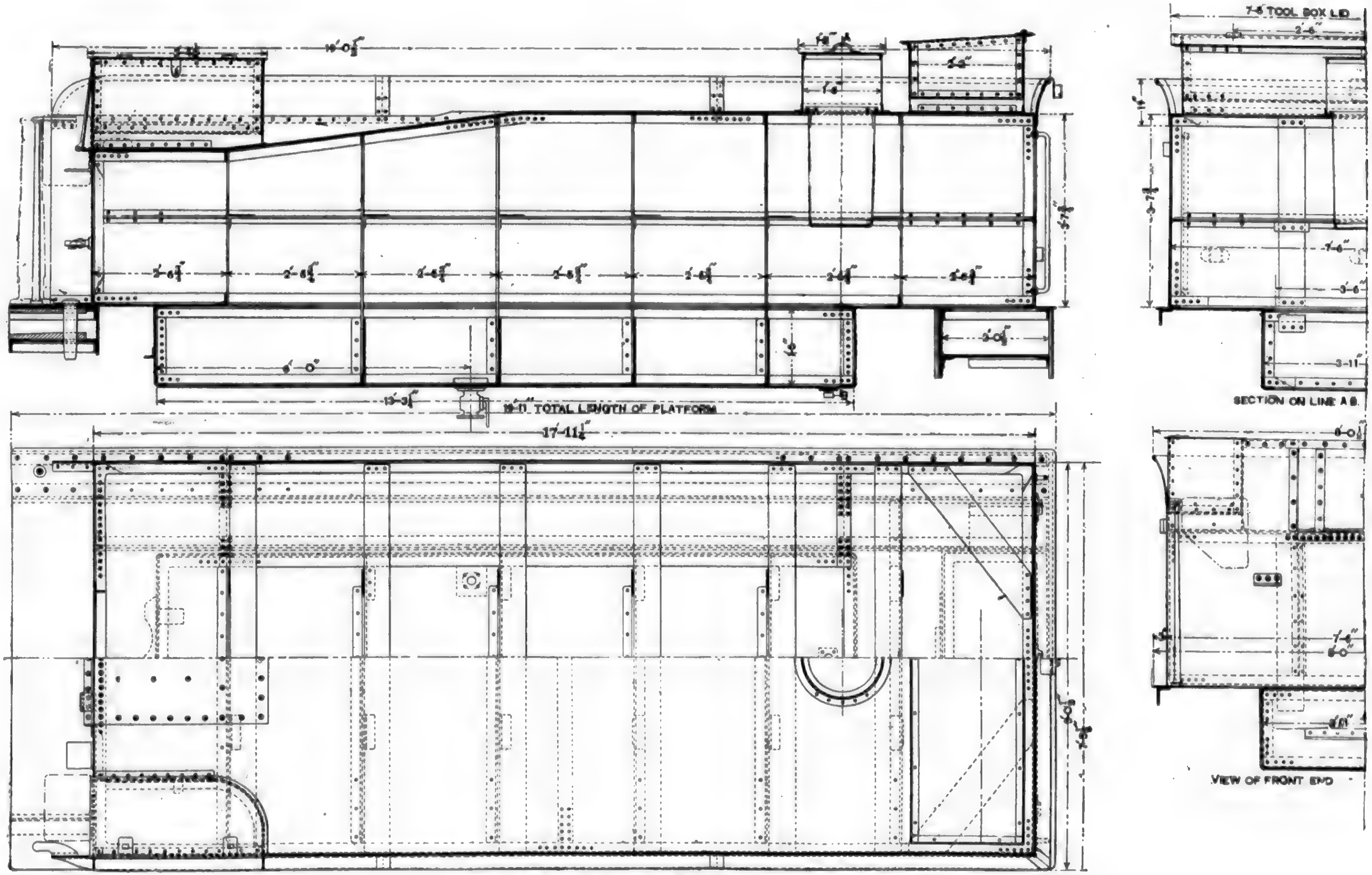
Dr. Leech explained at much length the mechanism of the human ear. His system will soon be introduced into some of the deaf and dumb institutions, and he feels sanguine that wonderful cures will be effected.

The Hydrophone.—The principal object of this ingenious yet simple apparatus is to give warning to a port or fleet of the approach of a torpedo-boat, even if the latter is totally submerged and therefore quite invisible. It consists essentially of two parts, one submerged in the sea at a proper distance from the port or fleet to be warned, and at a depth sufficient to escape the surface agitation. This part may be described as an iron bell-jar, which, on being plunged mouth downward into the water, retains a volume of air in the upper portion or bottom, where a copper box, protecting the sensitive organ of the apparatus, is fixed. The organ in question is merely a very delicate vibratory contact, which makes and breaks an electric circuit connecting the submerged bell with the indicator or second part of the hydrophone, situated on shore or on board one of the ships of the fleet. The contact is formed by a flat horizontal spring fixed at one end and loaded at the other by a heavy piece of brass, having on its upper surface a small platinum stud. A fine platinum needle kept upright by a vertical guide rests its lower end loosely on the platinum stud. The needle and the stud are connected in the electric circuit through the guide and spring, and when the needle dances on the stud the circuit is made and broken. An electric current from the ship or shore battery is always flowing through the circuit—that is to say, between the submerged bell and the indicator. Now the propeller of a torpedo-boat or of a torpedo sets up vibrations in the water, and these, reaching the submerged bell, agitate the trembling contact, so that the needle dances on the stud and interrupts the current. The consequence is that the indicator begins to work and announces the submarine disturbance. This part of the hydrophone consists essentially of an electro-magnet through which the current passes, with an armature free to oscillate when the current is rapidly made and broken—that is to say, when the current becomes intermittent. The motions of this armature can be seen by an observer if he chooses to watch, but actual observation is not required, for the indicator itself gives the alarm. This takes place when the swing of the armature carries it within the attraction of a magnetic contact piece fixed near it. The armature is then drawn to the contact piece and held fast there. The swinging armature and the contact piece are connected in the circuit of a local battery, and, when they meet, the current flows to ring an electric bell or light an electric lamp. The torpedo-boat thus announces its own arrival on the scene in spite of itself, and precautions can be taken against it.

The hydrophone is at present undergoing a practical trial in the Solent, and Captain M'Evoy, the inventor, estimates that three of the instruments suitably placed would be sufficient to protect Portsmouth Harbor. He is now engaged in constructing a larger bell than that already submerged, in order to meet the requirements of the government authorities. The whole apparatus is beautifully worked out, and comparatively inexpensive. Moreover, it is sufficiently sensitive to announce the passage of steamers a mile distant from the bell. Obviously such an instrument might also be used for submarine signaling, for a ship, by stopping and starting her propeller, could send a message in the Morse Code, and the shore could respond by flashing the electric lamp. In the case of another ship the response might be made by her propeller. —*The London Times*.



TENDER TANK FOR AMERICAN EXPRESS PASSENGER LOCOMOTIVE.



TENDER TANK FOR ENGLISH EXPRESS PASSENGER LOCOMOTIVE.

AMERICAN AND ENGLISH LOCOMOTIVES.

(*Continued from page 469.*)

Our engravings illustrating features of construction of English and American locomotives this month show the tanks which are furnished by the Schenectady Locomotive Works for engines of the type which have been the subject of this series of articles, and that which is made by Mr. Adams for the London & Southwestern engine. The following are the specifications for the two tanks:

AMERICAN TANK.

To be of 3,500 galls. capacity, strongly put together with angle-iron corners, and thoroughly braced and stayed, and well secured to tender frame. Tank fitted with water scoop.

ENGLISH TANK.

The tank to be of the form shown. The tank plates to be of the Best Best Staffordshire iron. Each side plate of the tank is to be in one, $\frac{1}{4}$ in. thick. The bottom plate of the tank to be $\frac{3}{8}$ in. thick, jointed as shown, and to form the foot plate of tender. The height of top of foot plate from rail to be 4 ft. 1$\frac{1}{2}$ in. The end and front plates to be $\frac{1}{4}$ in. thick. The top to be made of two plates $\frac{5}{16}$ in. thick, jointed as shown. A stiffening plate $\frac{3}{8}$ in. thick to be riveted to the top of the tank at the front end. The tank to be thoroughly stayed by plates, angle and T-irons in the manner shown. The front plate is to be cut out to form a doorway by coaling, and is to be fitted with a door hinged from the bottom and secured at the top by suitable fastenings. Two wrought-iron tool-boxes are to be provided at the front of the tank, one on each side of the tender. Another tool-box is to be fixed across the tank on the top of the back. All tool-boxes to be fitted with false bottoms, perforated with small holes, and to be perfectly watertight at the top; the tool-boxes are to be provided with padlocks and keys. The tank to be provided with a manhole or tank filler and lid 1 ft. 6 in. in diameter, to which is to be attached a suitable sieve, as shown. The angle irons throughout to be 2$\frac{1}{4}$ in. × 2$\frac{1}{4}$ in. × $\frac{3}{8}$ in. The tank to be riveted up with $\frac{5}{8}$-in. rivets 1$\frac{7}{8}$ in. pitch, countersunk outside in the sides and end of the tank. The coping plates which are attached to the sides and end of the tank to be finished with a wrought-iron half round moulding piece, as shown. A well to be provided 13 ft. 3$\frac{3}{4}$ in. long, 3 ft. 11 in. broad and 1 ft. 6 in. deep, of plates $\frac{1}{4}$ in. thick, stayed and riveted in the same way as the tank. One filling cock for bucket is to be fixed on right-hand side in front of tank, as shown. A washout plug is to be fitted to the bottom of the well.

One hand rail is to be fixed on each side of the back of the tank and is to be finished bright; four lamp irons to this company's pattern are to be fixed on the back of the tank and one lamp iron on each side of the tank, as shown.

The "well" of the English tank, it will be seen, is a feature in which it differs from the American design. This can be used when the wheels are arranged as in the English tender, but is impracticable when the tender is carried on trucks, as the frames, center plates, etc., of the trucks must be in the space, or part of it, which in the English tank is occupied by the well. The latter increases the capacity of the tank, and the fact that it can be used with the form of running gear employed under the English tender is an additional advantage in its favor besides those which have already been pointed out.

Another feature in which they differ is in their form, the American tank being bifurcated, the space between the two legs or branches being available for carrying coal. This, therefore, rests on the floor of the tender, where it would seem that it can be broken and manipulated more conveniently than on top of the tender, where it must be carried in the English vehicle.

The engravings published this month complete our illustrations of the two engines. The articles will be finished next month with the specifications, which will be given complete.

NOTES.

A Steel Crank-shaft.—A steel crank-shaft has recently been turned out at the Bethlehem Iron Works for the steamer *Paris*. It is intended for a spare shaft. The tensile strength is 90,000 lbs. per square inch. A 5-in. hole has been bored in it from end to end.

Large Ship Plates.—Very large ship plates have recently been made in England for the new steamers of the Chesapeake & Ohio Steamship Company. These plates are 60 ft. in length by 4 ft. wide, so that there is but one butt joint in a length of 120 ft.

The "Polyphemus."—The most singular ship in the world is the *Polyphemus*, of the British Navy. It is simply a long steel tube, deeply buried in the water, the deck rising only 4 ft. above the sea. It carries no mast or sails, and is used as a ram and torpedo boat.

Scrap Iron Chain Cables.—It is stated that the Navy Department will discontinue the use of scrap iron for the manufacture of chain cables at the Boston Navy Yard, tests having shown that chains made from scrap iron are inferior in tensile strength to those made from new bar.

Aluminum Boats.—London *Truth*, recently referring to this subject, says: "It may interest some readers to know that the launch that has been dispatched to the African lakes was built by Messrs. Escher, Wyss & Company, of Zurich. The boats of this firm are mostly constructed for use with naphtha engines, but they are equally suitable for steam or electricity, and we suppose that rowing boats could equally well be made of the same material."

Blowing Up of Derelicts.—As a result of the recent discussion among the various nations of the world, an order has been issued to Rear-Admiral Belknap at New London, Conn., directing him to send the dynamite cruiser *Vesuvius* on a voyage for the purpose of blowing 13 derelict vessels that endanger navigation. All these vessels to which the *Vesuvius* is assigned were wrecked on the Atlantic coast, and nearly all are adjacent to the New Jersey shore.

A New "Victoria."—The contract for the building of one of the new British ironclads will be placed with Armstrong, of Newcastle-on-Tyne. The new vessel will be 4,000 tons heavier than the ill-fated *Victoria*. The specifications contain several important changes in regard to the surplus buoyancy of the vessel. In speed and power of armament the new warship, which will cost about £1,000,000, will, it is said, be unsurpassed by any armor-clad vessel afloat. It is understood that the new vessel will be named *Victoria*.

Tank Ship for Cottonseed Oil.—The next novelty in the world of commerce is to be a bulk steamship to carry cottonseed oil from the United States to foreign lands. The American Cottonseed Oil Company has contracted with shipbuilders on the Clyde for the construction of such a vessel. The new steamship will have separate compartments for the storage of the oil, and there will not be such risk as there is in carrying petroleum in bulk. Every modern improvement will be applied to the tanker to insure both safety and speed. She will be owned solely in the United States, but will fly the flag of Great Britain.

Ferrules for Marine Boilers.—From foreign exchanges it is learned that ferrules—several forms of which were illustrated in the AMERICAN ENGINEER for May—have been officially adopted in the British Navy as a means of strengthening boiler tubes. The case of low-pressure engines will be individually considered as occasion requires, but in a general order that has just been issued ships with engines working with pressures exceeding 90 lbs. per square inch will be fitted with ferrules as soon as they return from foreign service or there is opportunity to place them in the hands of the dockyard officials.

New Steamers for the Hamburg-American Line.—The Hamburg-American Packet Company has recently ordered five new steamers for their Transatlantic service. Three of these will be built at Belfast, one at Stettin, and one at Hamburg. They will be 465 ft. long, with a beam of 52.56 ft., a depth of 35 ft., and a tonnage of 7,800, with a large freight capacity and accommodations for a large number of steerage passengers. They will have the most approved sanitary arrangements for carrying meat and other perishable provisions. These vessels will bring the total tonnage up to 206,000, or only 15,000 tons behind the Peninsular & Oriental Company, which at present owns the largest tonnage in the world.

Submarine Sentries.—The latest device in the way of submarine sentries emanates from the brain of a Scotch inventor. The electric current is employed to do the work, the apparatus consisting of submarine wires laid down in the bed of the sea or river through which intermittent currents are made to pass. These currents are detected by means of a detector, which may be on the ship, or let down by a rope or coiled around the hull of the vessel. It is claimed that by this means, when a vessel comes into the neighborhood or over the top of the wires, those on board can detect the presence of the current, and in conse-

quence can locate their position. The currents may have, if desired, different characteristics, so that the captain may distinguish in a fog whether the vessel is approaching a shoal or other submarine obstruction.

Coaling at Sea.—In connection with this subject the *United Service Gazette* (British) says: "Some interest has been aroused by experiments which were made during the manœuvres with a 'transporter,' the invention of Mr. Temperly, a shipowner. Such satisfactory results were obtained that the Admiralty have retained the appliance for further trials. It will be remembered that coaling at sea was attempted off Madeira during the manœuvres of three years ago, the discharging and receiving vessels being partially protected from one another by rope fenders of prodigious size. However, though the weather was exceptionally fine, the operation proved both difficult and dangerous, and the 'transporter' now under consideration was devised to obviate the necessity for the two vessels coming to such close quarters. It is composed of an iron girder about 30 ft. long and fitted as an overhead tram way, and it enables the two vessels to lie 25 ft. apart. It is found that with its aid coaling can go on under steam, some torpedo boats, indeed, receiving their supplies when proceeding at 10 knots an hour."

Lengthening a Steamship.—The London *Times* is authority for the following information: "The North German Lloyd mail steamer *Bayera* has just undergone an alteration of a kind that will no doubt be of interest to shipbuilders and shipowners generally. This vessel having proved herself rather too small for the Eastern traffic, her owners decided to lengthen her by 50 ft., a work requiring six months to complete, and this has been successfully accomplished at the shipbuilding yard of Messrs. Blohm & Voss, at Hamburg. Being placed in dry dock, the steamer was severed amidships forward of the engine-room, and the forepart drawn forward the required distance by hydraulic appliances. A whole compartment, 50 ft. in length, was then built on between the two portions, and the necessary strengthening effected throughout. The *Bayera* is now 450 ft. in length, and her carrying capacity for cargo has been increased by 2,400 c.m. The extra length has also added largely to the passenger accommodation. It is stated that the *Bayera* is the first large ocean steamer in which such an important and extensive addition has been made. On her recent trial trip she attained a speed of about 15 knots."

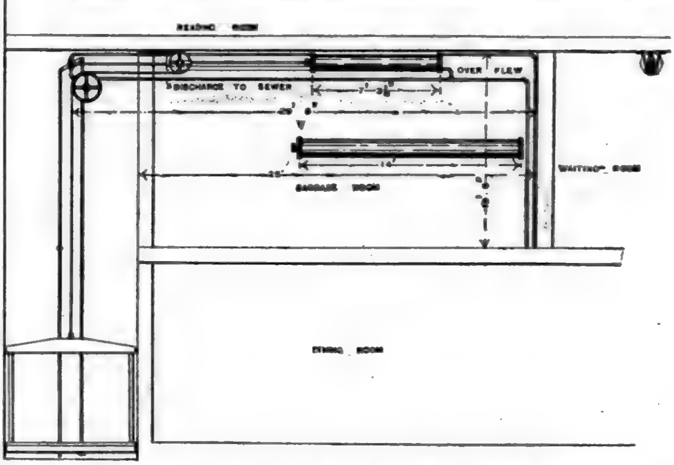
The Condition of the "Chicago."—A press dispatch says of this vessel, which is Admiral Erben's flagship, that it will probably be ordered home late in the fall, if the *New York* is ready for foreign service, to undergo extensive repairs to her boilers and machinery. Surprise was expressed when she was sent to the Mediterranean. Last December a board reported the boilers unsafe. A few hundred dollars was expended in patching them up to last through the naval review.

When orders came, after the disbanding of the fleet in New York Harbor, for her to proceed to Europe with Admiral Erben, the protestations of the engineer officers were loud against sending a ship with defective boilers to a foreign station. Her boilers will now only enable her to steam at a little better than half power, which leaves no boilers for reserve steam in case of accident. Of her six boilers, two have been useless since she left New York. The reports of the board last December stated that all of them were badly "fatigued," which means that the plates were in such condition as to render the boilers liable to explosion without further warning.

The engines were obsolete at the time the *Chicago* was constructed, and the boilers insufficient to generate steam to give her the speed the vessel should make. She has been in commission and on active service for eight years with few repairs to her machinery, and she cannot last much longer as a cruising ship unless new boilers are supplied. Plans have been prepared by the Bureau of Steam Engineering for entire new engines for the ship. With triple-expansion engines and new boilers she would be an 18-knot vessel, and one of the most useful cruisers in the service. Her best speed now is not over 11 knots. Fully $500,000 is necessary to make the *Chicago* practically a new vessel.

The Naval Armaments of Europe.—A British Parliamentary paper has been issued containing a return of seagoing warships in commission, in reserve, and building, and showing the naval expenditure, revenue, tonnage, of mercantile marine, and value of sea-borne commerce of various countries for the year 1893; also a return showing naval expenditure on seagoing force, the value of sea-borne commerce (exclusive of interchange with the United Kingdom), and the revenue of British self-governing colonies for the year 1893. It appears that Great Britain has in commission 24 battleships, four coast defense ships (armored), 63 cruisers (armored and unarmored), and 78 other ships, not torpedo boats; in reserve 10 battleships, 16 coast defense ships (armored), 49 cruisers (armored and unarmored), and 50 other ships, not torpedo boats; and building and completing for sea nine battleships, 19 cruisers (armored and unarmored), and 23 other ships not torpedo boats. France has in commission 19 battleships, five coast defense ships (armored), 23 cruisers (armored and unarmored), and 50 other ships not torpedo boats; in reserve, five battleships, three coast defense ships (armored), 20 cruisers (armored and unarmored), and 62 other ships not torpedo boats; and building and completing for sea eight battleships, two coast defense ships (armored), 19 cruisers (armored and unarmored), and five other ships not torpedo boats. Russia, in commission, five battleships, nine cruisers (armored and unarmored), 34 other ships not torpedo boats; in reserve, two battleships, nine coast defense ships, six cruisers (armored and unarmored), 37 other ships, not torpedo boats; building and completing for sea, eight battleships, four coast defense ships, two cruisers (armored and unarmored), four other ships not torpedo boats. Germany, in commission, 11 battleships, 14 cruisers (armored and unarmored), 19 other ships not torpedo boats; in reserve, three battleships, six coast defense ships (armored), 17 cruisers (armored and unarmored), five other ships not torpedo boats, building and completing for sea, seven battleships, three cruisers (armored and unarmored), one other ship not a torpedo boat. Italy, in commission, four battleships, eight cruisers (armored and unarmored), 16 other ships not torpedo boats; in reserve, nine battleships, five coast defense ships (armored), five cruisers (armored and unarmored), 26 other ships not torpedo boats; building and completing for sea, four battleships, 13 cruisers (armored and unarmored), three other ships not torpedo boats. Other countries covered by the returns are Spain, Austria, Netherlands, Portugal, United States, China, Japan, Chili, Brazil, Argentine.

BAGGAGE LIFT, PLATTSBURGH DEPOT, DELAWARE & HUDSON CANAL CO.



SPECIAL TOOLS OF THE DELAWARE & HUDSON CANAL COMPANY'S SHOPS.

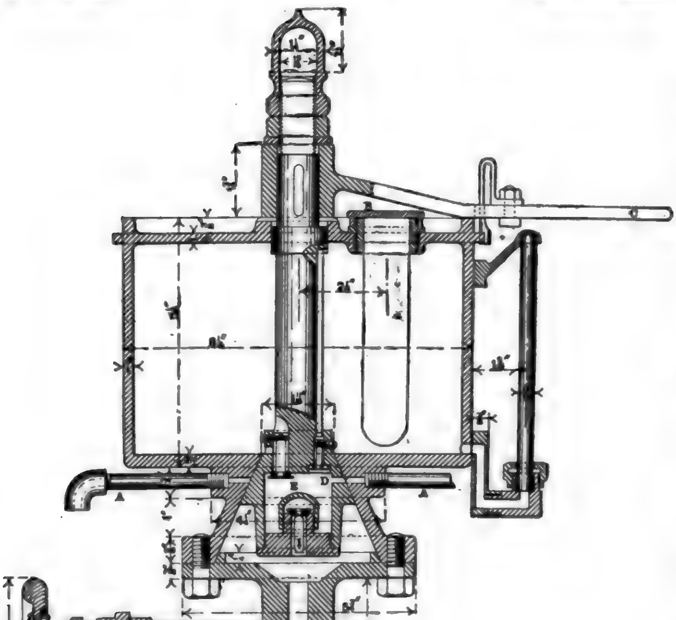
HYDRAULIC ELEVATOR AT PLATTSBURGH DEPOT.

We illustrate a very simple form of hydraulic elevator which is used for a baggage lift at the Plattsburgh Depôt, in which

a single cylinder, whose stroke is multiplied by 2, is used to lift the baggage from the station platform to the baggage-room, and also for lowering the same. The principal feature of the lift is the simplicity of its arrangement, which consists of a cylinder 7 ft. $3\frac{3}{16}$ in. long, bolted to the roof of the baggage room with a piston-rod reaching out and taking hold of a single sheave, over which the wire rope suspending the cage is passed. One end of the rope is fastened to the ceiling of the room, the other passes over a fixed pulley so that it is delivered down the center of the elevator shaft. The general arrangement of piping is clearly shown on the engraving, the valve being located at the top of the shaft and operated by a lever to which two rods are attached, which have a stop for shutting off the water at the top and bottom points of the lift of the cage. One pipe leads into the valve and from it there are two openings to either end of the cylinder with a discharge pipe into the sewer.

APPARATUS FOR OILING LOCOMOTIVE AXLE-BOXES.

There has been a great deal of difficulty experienced by all engine designers and runners of locomotives, that are intended for running long distances at high speeds, in keeping the driving-boxes cool. Arrangements have heretofore been made for introducing a stream of water at the top of the axle-box for cooling off, but this serves merely as a cooler and not as a lubricant, for unless water is supplied continually and in large quantities its lubricating qualities are soon worn away. The instrument which we illustrate, and which has since been put upon the market by M. C. Hammett, Troy, N. Y., was designed by Mr. Cory for use on the through express engines of the Delaware & Hudson Canal Company, and is so arranged that a quantity of oil can be thrown on to any one of the axle-boxes of the engine.



AXLE LUBRICATOR, DELAWARE & HUDSON CANAL CO.

The engraving which we give is a vertical section of the machine, and the prominent part of it consists of a large brass cylinder 8½ in. in diameter and 5 in. deep. The oil is contained in this. From the stand which is cast beneath this reservoir, pipes are led off as at *A A*, running to the box that is to be lubricated. A gauge-glass shown at the right is used to indicate to the engineer the height at which the oil stands in the reservoir. The filling of the reservoir is accomplished by unscrewing the cap *B* and pouring oil into the tube beneath it, which is provided with a strainer, so that all extraneous matter and dirt are removed before being sent to the journals. The handle *C* at the top is keyed to the stem, which passes down through the center of the reservoir and to which the conical plug-valve is attached. This plug-valve has an opening in one side *D*, through which the oil passes to the journal to be lubricated. When it is desired to oil any particular bearing, the handle *C* is turned so that the opening *D* is opposite the opening leading to the particular pipe *A* which is to be used. The oil, in the mean time, has come down through the downward opening valve and filled the space *E*. After the handle has been placed in position the valve handle *F* is turned, admitting steam through the pipe *H*, which passes up through the valve *I*, and entering the chamber *E*, by its pressure closes the valves opening into the reservoir and drives the oil out through the pipe *A* to the bearing upon which it is injected with a squirt.

The apparatus is the result of long-continued experiments and careful adjustment, and the reports of its use on the road are most satisfactory.

THE PHILADELPHIA & READING SHOPS AT READING.

THE shops of the Philadelphia & Reading Railroad, at Reading, Pa., were built many years ago, and the calculation was made at the time of their construction that they were large enough and could be made to have a capacity for doing all of the locomotive repairs required by the road until it should have an ownership of 450 locomotives. The road has outgrown this number by a very considerable amount, and recent reports from the locomotive department show that they have an ownership of between 700 and 800 engines. The shops are therefore called upon to keep in repair a number of locomotives, at least 50 per cent. in excess of that which its builders considered their maximum capacity. The shops occupy two blocks by the side of the main line entering the city of Reading, each 200 ft. × 400 ft., and on the opposite side of the track there is a small space which is covered by the blacksmith and forge shops. Like shops of many other roads which have outgrown their original capacity, the tools are closely crowded together, and there is an accumulation of interesting matter which the new shop, fresh from the hand of the tool makers, does not possess. We intend in the course of the next few issues to illustrate a number of the most interesting of the tools which are to be found in use in these shops. In work of this kind, where every inch of space is of the utmost value, and where tools must be worked to the best possible advantage, it is necessary that the most perfect system should prevail in regard to the handling of the work.

Shortly after the adoption of the piece-work system by the Pennsylvania Road it was also adopted by the Philadelphia & Reading, and largely prevails throughout the shops—in fact, everything is done by piece-work for which arrangements can be made. There is necessarily some day-work in the form of handling of material, as, for example, it is necessary to re-handle locomotive driver wheels and such classes of material several times more than it would be required were better storage space available. But wherever machine work or erecting work is to be done the whole is done by the piece. The pattern shop is about the only exception to this rule. There is a complete set of templates and gauges for standardizing all of the work of the shop, and workmen are not asked or called upon to use their rules except in very rare instances. Most of the gauges are of the well-known types and were nearly all made on the premises, a very few master pieces having been bought from the regular makers. The drawings from which the work is made are nearly all made to the standard size of about 9½ in. × 15 in. These are kept filed in books devoted to the different parts of the engine of which the drawings are made, and are readily filed away in drawers and do not occupy the space, and are made more readily accessible than large and miscellaneous sizes of drawings kept in the ordinary

method in drawers. The drawings are numbered consecutively, regardless of the subject of the illustration, and when a fresh blue print is needed an order is placed upon the blueprint book; the boy removes the drawing from the file, makes a blue print, and returns it to its place. Changes are made upon the original tracings, and all previously made blue prints are recalled from the shops and new ones issued. The blue prints are pasted on sheets of sheet iron and given a coat of shellac in order that they may be kept wiped clean. Sets of drawings are issued to each department so that when an order is sent out the drawing number and blue print number is put upon it, and it is not difficult for the foreman to select the drawing which is needed for the work.

The chemical and testing laboratory is also an important feature of the work, and is modeled after the Pennsylvania laboratory at Altoona, where the head chemist was previously employed. It contains the usual equipment of such a laboratory and one or two novel instruments designed on the premises, which we will illustrate hereafter.

FIG. 1

FIG. 2

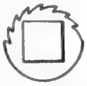


FIG. 3

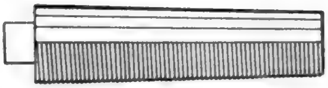


FIG. 4

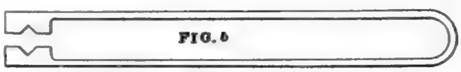


FIG. 5

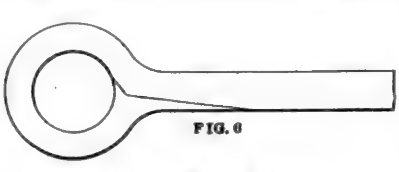


FIG. 6

Referring once more to the system of gauges in use on the road, we would call attention to the method which is used for lining up the pedestals of engines and the gauges used for that purpose. Fig. 1 shows a gauge which is made of the exact size to go between the forward legs of the pedestals of the engine which is to be lined. The point *A* is placed against a cube of a standard thickness, which is, in turn, laid against the leg of the pedestal. Inasmuch as the distance from *A* to *B* is the standard distance which should exist between the liners, it will be seen that the distance which exists when the gauge is in position between the point *B* and the leg of the pedestal will be the thickness of the liner at that point. This distance is then taken, and the liners planed up to proper thickness to it. When the liner is planed and put in position, the wedge with its rough face is bolted up against the opposite leg, and then a gauge, as shown in fig. 2, is used; the point *A* of this gauge is placed against the liner, and the distance from *A* to the point *B* is equal to the dimensions across the box; then, as the point *B* is in a line with the surface at *C*, it is used as a scratch-awl for marking a planing line at the top and bottom of the wedge. This is carefully noted with a prick punch and the planing line drawn. After this is done a check line is marked with a similar gauge one-half inch back from the planing line. The wedge is then taken down, sent to the planer and fitted up. The same system is carried on through all of the legs of the locomotive, and there is, therefore, never any cutting and trying and fitting to see that the wedges and liners are planed up to a proper thickness for the boxes, and the distance between the wheel centers is also accurately preserved. It is only necessary that two opposite faces of one corresponding portion of the pedestal legs should be in line.

In fitting driving-wheels to their axles the same system of boring the wheels and turning the axles to gauges is carried out, and the pressures are made to vary in accordance with the diameter of the wheel. The following notice is posted on the driving-wheel press:

STANDING WHEEL PRESSURES.

Driving-wheels	9 tons	per 1 in. diameter of	axle.
Truck	6 "	" "	" "
Crank-pins	9 "	" "	" pin.

Example.—Driving-wheels with 6-in. bore for axle should be put on at a pressure of 6×9 tons $= 54$ tons.

Crank-pins with 4-in. diameter for wheels should be put on at a pressure of 4×9 tons $= 36$ tons.

A comparison of the gauges which are made to do this work shows that for each inch of diameter the bore in the driving-wheel should be about .001 in. less than the diameter of the axle upon which it is to be placed. Ordinarily for road work the tires are bored out straight and shrunk into position by the use of a gas for expanding; but on switching engines, where the tires wear out more rapidly, a taper slip tire is used, the taper being three eighths of an inch in the 5½ in. of width of the tire. These tires are bored out so as to fit the wheel centers accurately, and are held in position by set screws passing through the rim of the wheel and entering the tire from the inside. By slackening off these screws and striking the tire a few blows it is very readily removed.

Especial attention is paid to the testing of the steam gauges for the engines. Very many of the engines have the cab along on the center of the boiler, so that it is necessary to have two gauges, one in the engineer's cab and one back by the tender for the use of the fireman. In order that these gauges may be kept in proper condition, they are inspected very frequently. Formerly it was necessary to remove them both from the engine and take them to the testing gauge in the shops, but lately a new attachment has been placed upon the boiler so that a test gauge, which is itself compared very frequently with the standard test gauge of the shop, can be screwed into this attachment. If the two gauges upon the locomotive register the same pressure as this test gauge they are considered to be correct; if not, they are removed and corrected by the test gauge in the shop until they show the pressures to which they are subjected very accurately.

As it is necessary to do a great deal of boiler work in the erecting shop, it has been found desirable to have rivet-heating furnaces at frequent intervals at the pits over which the engines are run for repairs. There is at one end of the shop a blower supplying a blast to a pipe running down the whole length of the shop, and from which air is drawn for the purpose of supplying the Bunsen burners of the tire-heating apparatus. At nearly every column of the roof bents there is placed a small cast-iron pot lined with fire-brick, into the bottom of which a blast pipe is led from the air pipe running down the shop, so that whenever any riveting work is required on any pit there is a small forge close at hand ready for use for heating rivets or doing any other light blacksmith work that may be required. These pots are about 18 in. in diameter and about 22 in. deep. Their tops are about 30 in. from the floor, and they are so located that they are out of the way of workmen and do not impede the movements of trucks about the shops or in and out of the gangways. It is a very great convenience, and is very much neater than the ordinary portable forge, which must be carried to the point at which the work is to be done.

All of the boiler studs which are put into the boilers are made with a taper of three-quarters of an inch to the foot, and taps are so arranged that a workman cuts the thread to the exact depth necessary for the screwing-in of the stud without leaving any threads exposed. This is done by placing a check nut upon the top and screwing it in until this nut comes down hard against the surface of the plate. The workman then knows that he has gone in to the proper depth, and when the thread is cut upon the threading machine the thread is so cut by the die that it will exactly fill this hole.

In connection with this matter of tapping out holes in the boiler we illustrate a special reamer which was designed and made at this shop for reaming out holes which have been chipped in a boiler. It is very well known how difficult it is to get a half round reamer to work well in a roughly chipped hole. No matter how careful the workman may be in its manipulation, before the hole is thoroughly reamed out and in condition for a tap the reamer is sure to catch very many

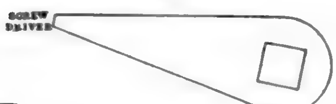
times, and the probability of breaking off the edges is very great. With the reamer shown this difficulty is entirely avoided. The hole is laid out in the usual manner, and two cross holes cut straight with a cape chisel. The corners are then trimmed off and it is ready for the work of the reamer. Fig. 3 gives a cross section and fig. 4 a side elevation. The smooth part of the reamer is cut with a thread, shaped, as shown on the side elevation, of about 12 threads to the inch. The cutting portion of the reamer occupies the other half of the circle. This device will square itself in the hole if it is handled with any sort of care, and it is not necessary to hammer it or crowd it in any way, as the thread on the smooth portion is sufficient to draw it down into the hole. There is no danger of its crowding to one side or catching, as there are ample cutting surfaces, and it has no tendency to work toward the point of least resistance, as will inevitably be the case with the ordinary half reamer.

Another handy tool for use in the blacksmith shop is shown in fig. 5, which is intended for squaring up the heads of stay bolts previous to the cutting of the threads. As it is somewhat expensive to make a set of dies for use under a steam hammer, this little device was designed. It consists of two blocks about 1½ in. wide and 3¼ in. long, with the square notches cut in them, as shown by the engraving. These are welded to a strip of steel ¼ in. thick and 1¼ in. wide bent into a U form, having a depth of about 30 in. The natural position of the device is open, throwing the dies up to about 1 in. apart. The hammerman holds the end of the U in one hand, and manipulates the hammer lever with the other. The blacksmith takes the heated stay-bolt and places it in the dies, which are struck a sharp blow and brought together. As the hammerhead rises the dies swing apart and enable the blacksmith to turn his work as much as may be required. The same principle is used in making tools for other purposes, such as putting of rings on to pins, etc.

Fig. 6 gives a detail of a scarf which is used for the weld that is made in hangers like those used for coal scales, etc. This scarf produces not only a very strong weld, but one which gives a smooth surface on the inside of the hole. It is, perhaps, a trifle more expensive than a plain flat scarf would be, but it holds very much better and the work is smoother. In the blacksmith shop also the bushings which are used for the spring hanger pins are made to their proper internal diameter over the mandrils, so that they do not require any other finishing for the entrance of the pins. They are driven over a solid mandril in the machine shop and turned off to their proper diameter. The pins are also formed in the dies, so that there is no necessity for any machine work being done upon them.

Any one who is at all sensitive to the effects of sulphur will at once notice the difference of the atmosphere of the Reading

Fig. 7.



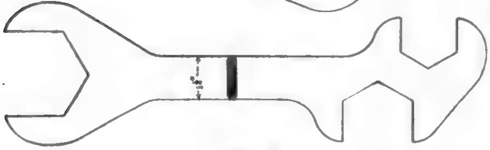


Fig. 8.

blacksmith shop and that of the ordinary shops. The atmosphere is almost as clear as it is out of doors, and even the most sensitive can spend an indefinite length of time there without being troubled with the disagreeable coughing caused by sulphur fumes. The reason for this lies in the use of a very close hood arranged over the forge, which is of special design, and which we will illustrate later, by which the draft is so maintained that all of the fumes and products of combustion from the coal are carried up the stack and into the atmosphere. This is perhaps a small matter, and may not affect the amount of work done by the blacksmiths, who soon become accustomed to sulphur fumes, but it certainly is a very attractive feature to visitors who are at all sensitive to the ordinary fumes from blacksmith coal. A great deal of die work is done in the

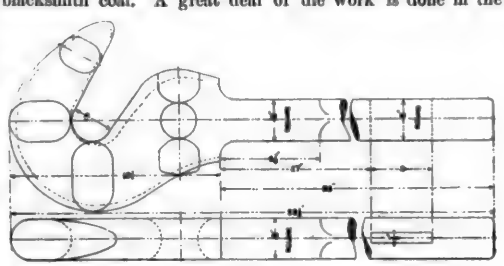


Fig. 9.

blacksmith shop, dies being made for almost all of the standard sized wrenches as well as for some of the heavier work on cars and locomotives.

We give in figs. 7 and 8 two samples of wrenches which are made under the die from spring steel. Two sets of dies are required for this work. The first is simply a cutting die for shaping the material, and the second is used for squeezing it

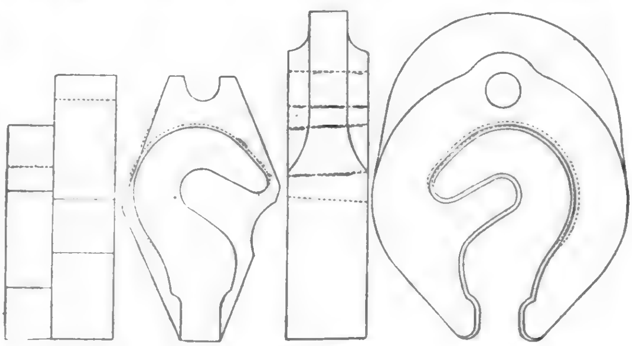


Fig. 10.

out and rounding the edges. Probably the best piece of die work which is done in the shop is the draw-hook for the coal cars, which is shown in fig. 9. This draw-hook is made from slabs which have been hammered up from scrap iron under the steam hammer, and are then welded together into a spade-shaped form. After this is done they are rebeated, the key-way in the tail of the shank punched, and the hook itself punched out of the solid plate by the dies, of which we also give engravings, fig. 10. Then in the same heat they are placed under another stamping die and the edges of the hook rounded, so that when they leave the hammer they are all ready for use under the cars. This is very much more rapid work, and the company claim that a stronger hook is made than in the old method of drawing out and turning up the hook, as is usually done. Of course the manufacture of a hook in this way can only be done economically when large quantities are used; but inasmuch as the Reading Road has several thousand cars equipped with these hook draw-bars, and as the demand for them for repairs is constant, there is work enough to keep one hammer and a furnace busy nearly all of the time in getting them out.

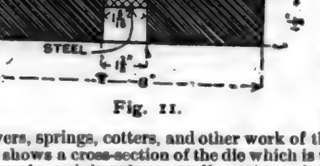


Fig. 11.

The other die work which is done in the shop consists of keys for springs, which are punched and rounded out in one heat, catches for switch reverse levers, springs, cotters, and other work of the same type. Fig. 11 shows a cross-section of the die which is used for forming the wrenches, giving the cross dimensions of the same. The steel piece that does the cutting is so arranged that it can be replaced when worn out, and also the clearance is such that the die can be repaired several times before it is rendered entirely useless.

FRENCH CORRIDOR TRAINS.

We have frequently adverted to the irrational mode of building intercommunication carriages. Although it represents a well-meant attempt to combine the advantages of American and European rolling stock, it nevertheless constitutes a constant source of danger, for an equal distribution of the weight on both sides is impossible. This applies more especially to corridor carriages running on six wheels. Several carriages of this type have been built lately for English lines. It is a puzzle to find out why our railway engineers did not adhere to the use of bogies for these cars.

This system of corridor cars is open to criticism; but the one we are going to describe is decidedly the worst combination that could be imagined.

In 1889 the Paris-Lyons-Mediterranean Railway built and exhibited intercommunication cars on the corridor system, running on four-wheel bogies. The corridor did not extend over the full length of the train; it had a Z shape—that is to say, the corridor extends first up the middle of the car, and then opens into a transverse passage, to run afterward along the other half, and on the other side of the carriage.

It does not seem that this design has been successful, for the Paris-Lyons-Mediterranean Company have recently put on their lines six-wheel corridor carriages in which the corridors are all on one side. They are only first and second-class, but we hear that the third-class are also being built. There is, however, a great difference between these carriages and those recently built in this country. The innovation consists in retaining the doors as they are in the ordinary compartment system. In other words, there are in each carriage four sets of doors: The external ones on each side of the carriages, those of the compartments opening on the corridor, and finally those at each end of the carriage. In other words, access to the compartments is obtained from either side of the carriages, the end doors being only a means of communication between one carriage and the others. For this purpose the end platforms of the carriages are connected by a small bridge, covered with a leather awning, which is formed like a concertina, so as to follow the variations of distance between the cars while the train is running on curves, etc. The same arrangement is used in the German corridor trains.

This design at first sight presents some advantages over the usual corridor trains, but we shall see that these are more apparent than real. The retaining of side doors of the antiquated compartment system will, indeed, facilitate the ingress and egress of passengers, while the end doors enable them to go from one carriage to another, or to the dining car, if there be one forming part of the train. But this multiplicity of doors makes the carriages rather uncomfortable; it weakens the body, and as the outer doors necessarily open outward, the width of the body had to be reduced; it cannot be 10 ft., as in the German corridor carriages. The width of the corridor is also very much reduced. These cars will, however, be suitable for running over the French Northern and the Swiss railways, the boundary line of clear headway of these railways being somewhat smaller than the German standard one.

The first-class carriages contain 4 compartments and 25 seats; the second-class has 5 compartments and 41 seats; the odd seat in both cases being provided at one end of the car, while the other end is fitted with a lavatory and water-closet.

The wheel base of the first-class is 22 ft. $7\frac{1}{4}$ in., that of the second class 23 ft. $8\frac{3}{4}$ in. full. No special device is employed to facilitate the inscription of the end axles in curves. The middle axle has a side play of about $1\frac{1}{4}$ in. in axle guards, and the end axle the usual play of $\frac{3}{16}$ in., as in ordinary carriages. The maximum width of the carriages is 9 ft. $5\frac{1}{4}$ in. full.

Each first class compartment contains six places covered with gray cloth; each second-class compartment contains eight places covered with blue cloth. The first-class seats are also provided with springs, and a system of jointed levers allows of the seats being pulled forward so as to render them more comfortable for night journeys. The internal woodwork is of mahogany for the first-class and pitch pine for the second-class.

The lighting is effected by oil gas, the reservoirs being fixed on the roof of the carriage and extending over its whole length.

No improved method of car heating has been adopted; this company seems to stick to the antiquated hot-water foot-warmer. The renewal of these during the journey entails the same disadvantages as those prevalent with the compartment system.

No special means has been provided to lessen vibrations. The body does not rest directly on the wrought iron underframe: pads of india-rubber are inserted between the first class bodies and the sole bars. In the second-class the pads are of wood. (Why this distinction?) The springs are 8 ft 2 in. long, and the plates which compose them are $3\frac{11}{16}$ in. wide × $\frac{1}{2}$ in. thick. We fear these springs will be too stiff.

The wheels, 3 ft. $\frac{3}{8}$ in. bare, in diameter, are known as Arbel Patent Anti-Dust wheels. They are made of wrought iron, but the space between each two spokes is fitted externally with a web, which causes the wheels to look like plain disk wheels. They are very strong, and do not churn the air as spoke wheels do. The journals are $3\frac{11}{16}$ in. in diameter, and 7.21 in. long.

We will conclude with the following particulars:

	1st Class.	2d Class.
Length over buffers........	38 ft. $8\frac{1}{2}$ in.	40 ft. $\frac{3}{8}$ in. full
" of body............	34 " 5.4 "	35 " 9 " "
Internal height............	9 " $5\frac{1}{4}$ "	9 " $5\frac{1}{4}$ "
Weight, empty	15.84 tons	15.80 tons
Dead weight per passenger..	12.65 cwts.	7.7 cwts.

The carriages are also fitted with the Westinghouse system of pneumatic intercommunication, whereby a passenger can in a case of emergency put the brake partly on without, however, stopping the train, thereby warning the driver that something is wrong in the train. This system and that of Wanger are largely adopted in France, and are far superior to electric and other systems of intercommunication, which are not connected with the continuous brake.—*The Railway Press.*

THE HANDLING OF FUEL ON THE FRENCH, ENGLISH AND BELGIAN RAILWAYS.*

By M. Jullian.

The fuel burned by locomotive engines represents a considerable proportion of the expense of the mechanical department, and one which it is very desirable should be reduced as much as possible. These expenses may be divided into three heads:

1. Purchase of the coal.
2. Transportation to the points of consumption.
3. The different methods which are used to place the coal when it has reached its distributing point on the cars into the tenders on the locomotive engines.

The subject of the devices which shall be used for the conveyance of the coal from the cars to the tenders at the stations or yards where this is done will be the subject of this paper. This manipulation includes the following operations:

1. Shunting of the loaded cars upon the tracks of the yard.
2. Unloading of these cars either into heaps or into the lorries which are used for carrying the coal to the tenders.
3. The loading of the tenders by means of these lorries, which are filled either directly from the car or from the heaps.

The shunting of the cars is almost entirely engine work. In every yard the service is always so regulated that the cars can be hauled by locomotive engines upon the tracks of the coaling station and as convenient as possible to the place of unloading. But the brakeman or workmen in the yard are always obliged to do a portion of this work to a greater or less extent by pushing the cars to the exact point of unloading. This last operation is very expensive, although it does not generally figure in the expense account. But it is none the less certain that whether the method adopted in the yard is piece work or done by the day, it is necessary to take this supplementary work into account both in the price paid and in the number of workmen employed. It is, therefore, of the utmost importance when the arrangements of the tracks of a yard are taken into consideration, to so locate them that the movements of the cars shall be as easy as they can be made, and shall be carried on as far as possible with engines.

Before entering into the details of these different operations, it is well to note how they can be simplified every time it is necessary to take coal from the car and put it directly into the tender; as we shall see further on, the ease of handling will in this case be diminished by one half. But it is not always possible to work in this way; for example, when the coals used only make a good fuel when mixed with others in proportions which have been established by experience, or when the irregularity of shipments compels the holding of considerable quantity in stock, necessitating the handling for filling up the storage place and removing it from these same places when shipments are stopped. We therefore see how important the regularity in shipments are from the standpoint of expense of handling.

The different systems of handling used to carry the fuel from the cars to the tenders, whether or not by way of storage heaps, may be divided into two classes:

* *Revue Générale des Chemins de Fer.*

(*A*) Handling effected without the use of fuel platforms or coal tips. The coal being placed in lorries, baskets or bins, and conveyed to the tender either by hand or mechanical appliances.

(*B*) Handling which is accomplished by means of an intermediate discharge into baskets or bins placed upon a fuel platform or coal tip, whence the fuel is then taken to be dumped into the tenders, these different operations being made as before indicated by men or mechanical power.

It is hardly necessary to say that in these two systems, if it is required to make a preliminary unloading on to heaps, that this unloading is always done without the intervention of a coal pit either by hand or mechanically. The object of this paper being to study mechanical means of handling, no attention will be paid to those where men do all of the work. Therefore, in order to show the differences which these operations present either in cars or in the time required, it is essential to report on each one of them.

HANDLING DONE WITHOUT THE USE OF A COAL TIP.

Transferring by Hand.—With this system the fuel taken from the car is thrown into baskets holding about 88 lbs., a weight which has been recognized by experience as that best adapted for the good utilization of the strength of a man, and these baskets are loaded upon the shoulders of the workman and are carried to a definite point of unloading, whether it be the heap, the tender, or the tip. This system has the disadvantage of being expensive and very slow, since men with a load of 88 lbs. have to traverse a greater or less distance and raise themselves with their weight to the point where the unloading must be done. Thus, when they are used for loading tenders it is necessary to increase the number of workmen, and this almost always increases the expense of unloading. The loading of a ton of coal into a tender with this system requires at least six men working for from three to four minutes, as the case may be, and costs $.12.

Transferring Mechanically.—This system is only used in France by the Northern and Eastern Railway Companies, and is still, in the case of the latter, in a period of probation, and only installed at the Chaumont Depot. The two systems are, furthermore, slightly different. That of the Northern admits the loading at any point of the yard; that of the Eastern Road, on the other hand, has only one point of loading.

Arrangements of the Northern Railway Company.—In the June, 1888, issue of the *Revue Générale des Chemins de Fer*, there was a paper giving very complete details of the conditions which the engineers of the Northern Company intended to fulfil for the unloading into heaps and the loading of tenders, and the methods which they had adopted; these methods consist in transporting the fuel from one point of the yard to another by means of tubs and steam traveling cranes. All the reports in regard to the organization of the yards and the types of material used will be found in the paper referred to. It is only necessary to add, to complete it, the expense of the various methods of handling with the crane, and to show the advantages and disadvantages of the method as adopted by the Northern Railway Company.

The average cost is $.0475 per ton for handling, which includes the unloading from the cars into heaps or into the tenders, or the loading of the tenders with the fuel taken from heaps. As almost all the fuel put into the tender was first unloaded into the heaps, we can say that every ton of coal delivered to the tender costs $.095 for handling, to which must be added the expense of operating and maintaining the crane. The table which is given below and which was furnished by M. de Bousquet, Engineer-in-Chief of locomotives and rolling stock, gives a very exact idea of the actual cost of handling in the different yards of the Northern Road, showing a comparison with the expense in 1885, when the mechanical devices were not in use, as well as the time and expense saved by the methods to which we are devoting our attention:

COMPARISON OF EXPENSE FOR HANDLING FUEL.

In 1885, last year when all the handling was done by hand.
In 1889, year when mechanical handling was in operation at La Chapelle, Fives, La Plaine, Somain, Amiens and Tergnier.

The Depot.	Tonnage of Coal delivered to Engines.		Difference between that and 1885.		Expense of Handling.		Difference between that and 1885.		Cost of Handling one ton of Coal.		Difference in per cent less than in 1885.
	1885.	1889.	More.	Less.	1885.	1889.	More.	Less.	1885.	1889.	
	Tons.	Tons.	Tons.	Tons.	$	$	$	$	$	$	
La Chapelle	48,687.65	58,512.45	9,824.80	....	9,870.57	7,460.61	....	2,409.96	202.73	127.49	35.4
La Plaine	29,130.00	32,913.70	3,783.70	....	4,588.65	3,411.96	....	1,266.69	157.51	100.79	35.9
Fives	43,851.00	57,100.50	13,249.50	....	6,910.45	5,216.79	....	1,693.66	157.51	91.20	Average { 42.0
Somain	27,319.75	31,698.75	4,379.00	....	3,978.14	2,128.74	....	1,849.40	145.35	67.07	53.8
Amiens	48,429.50	49,972.90	1,543.40	....	9,625.84	5,689.42	....	3,936.22	198.84	*113.81	42.7
Tergnier	44,519.50	38,797.45	....	5,722.05	6,634.10	4,533.39	....	2,099.70	148.96	117.04	21.5
Total of the other stations	174,285.50	237,876.45	43,590.95	....	29,758.49	32,222.87	1,464.38	....	176.70	147.82	16.3
	416,222.90	486,872.20	76,371.35	5,722.05	72,366.25	60,574.90	1,464.38	13,255.63	173.47	123.88	28.6
	+70,649.30 tons.		+70,649.30 tons.		−11,791.25		11,791.25		49.59		−28.6

* Figures for 1888.

To complete the report, the expense of maintenance and operation of the crane must be added, and this is given in the following table:

COMPARISON OF THE EXPENSE OF OPERATING AND MAINTAINING THE CRANES, AND THE EXPENSE PER TON FOR HANDLING IN 1888 AND 1889.

Depots.	Tonnage of Coal Distributed to Engines.		Expense of Operating and Maintaining Crane.		Expense per ton Handled.	
	1888.	1889.	1888.	1889.	1888.	1889.
	Tons.	Tons.	$	$	$	$
La Chapelle	56,502.20	58,512.45	1,733.54	1,657.28	30.59	31.35
La Plaine	30,384.10	32,913.70	782.77	733.29	25.65	27.36
Fives	54,423.40	57,100.50	841.21	1,213.84	15.39	21.09
Somain	31,611.50	31,698.75	546.47	554.01	17.36	17.29
Amiens	49,972.90	47,806.40	1,059.21	1,092.30	21.09	22.80
Tergnier*	17,408.50	38,797.45	470.72	1,089.93	17.17	26.79

The method adopted by the Northern Railway has very appreciable advantages in unloading into heaps when we merely consider the rapidity and expense of operation. The correct reports given in M. Flaman's paper show that unloading of a car of 10 tons capacity into a heap can be accomplished in 25 minutes, and involves an expense of from $.589 to $.5985, including the expense of maintaining and operating the crane. Now the same work, when done in baskets, requires at least 40 minutes, and costs on an average about $1.01, including the expense of maintaining the baskets. The advantages of this method are more evident when we consider the good mixtures which can be made by heaping up. It may be remarked, in this connection, that the yards on receiving coal of very different qualities can only produce a good fuel when they are thoroughly mixed, as at Amiens, Somain and Lille, this work being done with a shovel as far as possible, the crane only being employed in cases where haste is required.

The crane will load a ton of coal on to the tender in 2½ minutes or four tons in 10 minutes, and costs about $.06. The same work, when done with baskets located in advance on a platform, would not take very much longer, and it would be, it is true, but very slightly more expensive. The use of this

* For engines, the distribution given for 1888 is that of the second half year, the only portion of the year where mechanical distribution of the coal was in operation.

method is applicable at stations which have, as almost all those of the Northern Railway Company have, several entering tracks which are located between the coal piles or the sidings for the cars; there is, therefore, no disadvantage in having engines come in on the track which is used by the crane. On the other hand, at those stations where the heap of coal is scattered over the whole extent of the yard it cannot be traversed or served by tracks which can be used for engines, so that the use of the crane is not applicable to loading upon the tender. To conclude the consideration of the methods of the Northern Road, it only remains to speak of the night work and the quantity of coal handled.

Night work is especially easy to accomplish by means of the crane; it is sufficient to place a brilliant light on a post—a locomotive headlight, for example—so that the manipulator of the crane can handle the tubs and locate them expeditiously and safely. By placing another light of the same brilliancy near the workmen who are filling the tubs, the whole work of filling and unloading can be carried on in the best possible manner.

It is difficult to determine the number of tubs delivered by the crane by taking the number of turns made by the hoisting shaft; on the other hand, the use of tubs of different capacities, which may even be filled to a greater or less extent, may so complicate matters that the number of turns made by the hoisting shaft, even admitting that it is proportional to the number of tubs hoisted, would not bear a proper relation-

the third for freight engines. These piles are composed of mixtures made according to the instructions of the head of motive power department and according to the shipments as they arrive.

There are always six piles: three for distributing on one side and three being built up on the other; the size of the piles is therefore proportional to the amount of fuel for distribution which they contain. The work in the yard is regularly done by six men—a crane man and five laborers. It is often necessary, nevertheless, to supplement them by extra help if the receipts are too great.

The plant includes a crane of one ton capacity, having a swing of 26 ft. 3 in. and a height of lift of 9 ft. 10 in. This crane was not built for this especial purpose, but was in use in one of the shops and was utilized for this purpose; five Decauville coal tubs of 1,100 lbs. capacity are used both for loading and unloading; five Decauville lorries whose holders have been removed and replaced by wooden chock blocks upon which the tubs can be placed and carried to any point whatever of the yard. The operations when working are as follows:

Unloading on to the Coal Heaps.—All the unloading of the small pieces into heaps is done with a shovel; the crane is only employed for unloading cars containing large lump coal. To unload they proceed as follows:

Suppose that heap No. 1 is for distribution and No. 2 is being built up, the crane is located on track 22 and two cars

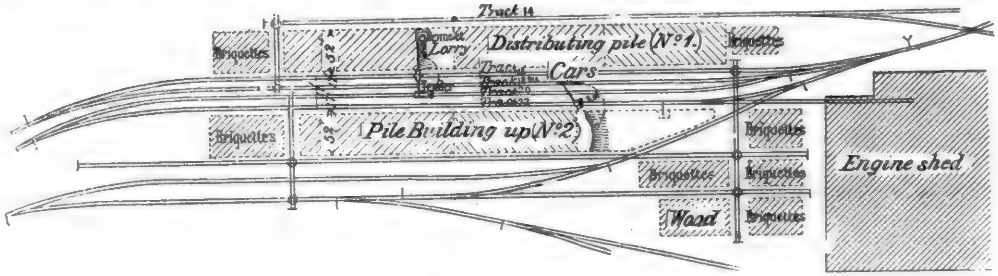


Fig. 1.—CHAUMONT COALING STATION, EASTERN RAILWAY OF FRANCE.

ship to the quantity of coal handled. Under these circumstances it is necessary to refer to the note-book of the crane-man to learn the number of tubs of each capacity which has been lifted during the day, and to the reports of the inspector who has charge of the loading of the tubs. It is probable that the oversight thus exercised may give satisfactory results where large quantities are handled and where we can take the average capacity of the tub as a basis of our calculations. But it may be permitted to ask whether it is sufficient to determine with perfect accuracy the amount of fuel delivered to each engine which has been loaded during the day.

Arrangements of the Eastern Railway Company.—The use of mechanical methods for handling fuel at other coaling stations was only begun about two years ago, so that the system which we are about to describe is one of recent installation and only exists at a single station—that of Chaumont—where it is in full operation.

The principle which seems to have been adopted is the following: on account of the mixing which must be done, all the fuel is unloaded into heaps as in the Northern Railway. The only exception is in the case of briquettes, which are loaded from the car into the tender as far as it is possible. The coal piles are bounded on one side by a track or two parallel tracks for sorting out or switching cars, and on the other side by three parallel tracks, the nearest one to the coal piles being used for the movements of the crane following the movement of the wagons in unloading, and the furthest one for the movement of engines. The arrangements of the tracks at the Chaumont Depot are those given in fig. 1. At this depot the yard has been doubled, and its ranges of coal heaps have been made on either side of the tracks of the cranes, cars and engines; on one side there are the heaps which are being built up, and on the other those from which supplies are being drawn. With this arrangement they have found it necessary to lay a fourth track for unloading cars, as will be noted further on.

The Chaumont Station distributes 80 tons of coal, including briquettes, daily. The coal is always divided into three distinct piles: one for high-speed passenger engines, the other for engines hauling local and accommodation passenger trains,

are switched in upon track 18 in the most favorable position for unloading. Two men are stationed on each car with a tub, and the duties of the fifth man are to take care of the unloading of the tub. The rest of the working is the same as upon the Northern Road—that is, the crane lifts a fuel tub from each car in succession, carries it to the coal heap and empties it there and carries it back to the car. The unloading of the two cars in this case is the most favorable possible, but occupies a little longer time than on the Northern Road, or from five to six minutes, on account of the capacity of the tubs, which only contain one-half ton. But a more unfavorable condition of affairs frequently occurs when it is necessary to unload the fuel at a point more than 26 ft. from the crane; in this case it is necessary to use lorries. The crane deposits the tub upon the framing of these lorries, and a man pushes them to the point where they are to be unloaded. The time occupied in this way is very frequently doubled.

For loading on the tender the crane is moved on to track 18 and the engines are run in on track 20, stopping within the radius of the action of the crane. This loading is done in exactly the same manner as on the Northern Road. The time occupied is practically the same, and it requires about 2¼ minutes to load a ton of coal on the tender, except in cases where it is necessary to use the lorries to go after the fuel and bring it within reach of the crane; but such cases as these are rare, for the men bring the coal within reach with shovels during that time of the day when there is nothing else to do. The briquettes are loaded by hand, so that they may not be broken.

We can see, then, that in its general arrangement this Eastern yard does not differ practically from those of the Northern Road; for unloading cars the crane does not stand upon the same track as the cars. This is because it is essential that the crane should be able to move freely from track 22 to 18 and inversely accordingly as there is a car to unload or an engine to coal; it is for this reason that they have laid a fourth track for storing the cars. Practically, however, the crane is very rarely moved, for they only use it for unloading when there are long intervals between the successive coaling of two locomotives. As for the supervision of the work it is more imperfect than on the Northern Road, since the crane has no revolu-

tion counter. Every time that the depot master or the gang foreman wishes to verify the work, a tub is taken at haphazard and placed on the scales, just as they would do if they were working with baskets. Piece work has not yet been established at the Chaumont Station, so that it cannot be determined as yet whether there is any economy resulting from this new system. The gang has been diminished by two men since the plant was installed, and the workmen are paid but $ 80 per day. Yet the saving which is effected may be estimated from the following figures: In 1886 the yard delivered 31,069 tons of coal to locomotives, and the expense of doing this was $2,574.69, which corresponds to an expense of $.08 per ton, to which $.004 per ton must be added for the maintenance and repairs of baskets and other miscellaneous expense, giving a total of $.084 per ton. In 1889, 29,591 tons were delivered to locomotives, and the expense for this work was $2,067.66, which corresponds to an expense of $.07, to which must be added $.01 for the expense of operation and maintaining the crane, or $.08 in all.

We therefore see that the saving is not very great; and it is solely on account of the slight amount of work which is done at this depot that permitted this loading with baskets to be accomplished with such a small gang, and, consequently, at such slight expense. The system adopted by the Eastern Road has all the disadvantages of the Northern. It requires a number of tracks for the engines. There is no guarantee that the mixture of the coals is well done in the coal piles, and it does not permit of an easy supervision over the quantity of fuel handled. Furthermore, the necessity for moving the crane and the use of lorries are also marks of inferiority. It is true that the first could be easily done away with by employing two cranes, as is done on the Northern Road.

(TO BE CONTINUED.)

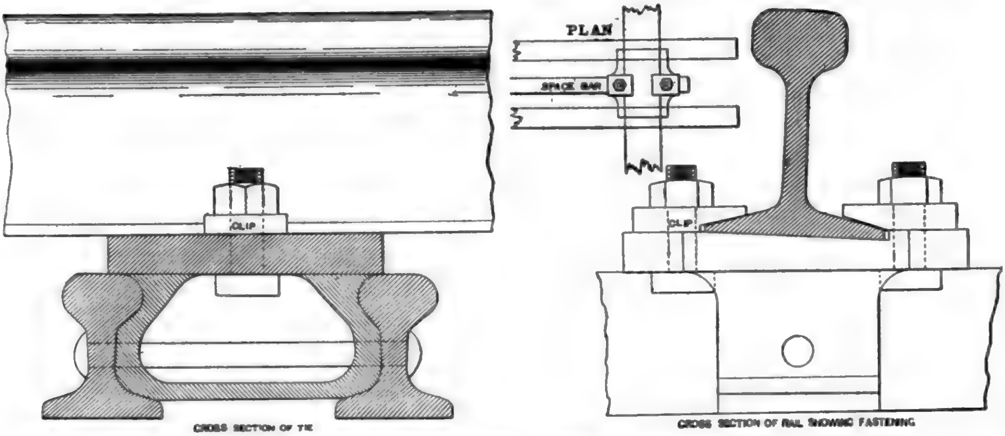
TESTS OF METALLIC TIES ON THE EASTERN RAILWAY OF FRANCE.

By G. Braet.

The Guillaume Tie.—The Eastern Railway of France, which in 1865 made some experiments with different types of metallic ties, paying especial attention to the Vautherin form, has recently resumed its experiments with a new type, in which it is sought to obtain a means of avoiding the disadvantages which were manifested in the first attempts.

This new tie, invented by M. Guillaume, and which we will describe, is shown in the accompanying engraving; its transverse section is in the form of a trough resting upon a plane surface, and it is entirely embedded in the ballast. The ends are turned down and oppose the movements due to the side thrust or the hindrance which the ballast can offer in the direction of least resistance. The rail attachments are made of movable lugs of cast steel, which are simply caught by their two tenons into the body of the tie. Finally, the holding down of the rails against these lugs is obtained by driving wooden wedges made of creosoted elm tightly in between the upper surface of the tie and the flange of the rails. These wedges, which give the rail an inclination of one in twenty, prevent all contact of metallic surface, which is an advantage from the standpoint of the preservation of the track material and the smoothness of running. The rails, which have a length of 39 ft. 4.5 in. and weigh 89 lbs. per yard, rest upon 16 ties. They are laid with suspended joints and broken. A hundred of these ties have been in use for about eight years, and have given satisfactory results.

Metallic Tie used on the Taviers & Embresin Railway in Belgium.—The accompanying engraving shows the metallic track which is used on the Taviers & Embresin Railway in Belgium. This railway, which has a length of 6.2 miles, starts from the Noville-Taviers Station of the Belgian State Railway, running from Namur to Ramillies, and is of a purely local interest; it is a single track, with the standard gauge of 2 ft. 4 in. between the inside edges of the rails. These are of the Vignole type, and have a length of 29 ft. 6.3 in., weighing 28 lbs. to the yard; each rail rests upon four ties which weigh 46.3 lbs. each, and it has supported joints. The ballast consists of ashes and broken stone, with a depth of 10 in. in thickness. The inclinations of the cross section of the Taviers & Embresin Railway do not exceed 1½ per cent., and the up-and-down grades are separated from each other by level places of at least 164 ft. in length. The sharpest curves have a radius of not less than 328 ft. on the main line, and where there are two curves following each other in the opposite directions there is a straight line of at least 164 ft. in length between the two. The daily number of trains running over the road is 13 passenger and 6 freight trains. The maximum authorized speed is miles an hour. The metallic ties are composed, as the engraving shows, of old iron rails cut to a length of 4 ft. 11 in. and fastened together in pairs by means of wrought-iron chairs weighing 8.8 lbs. each and held by rivets, their upper surface having an inclination of one in twenty.



METALLIC TIE USED ON THE TAVIERS & EMBRESIN RAILWAY, BELGIUM.

The rails are held to these chairs by means of clips and bolts. On curves the rails rest on nine ties instead of four, and under the supporting surface of the chair there are stay-bolts for maintaining the distance between the two lines of rails constant.

This track was laid in 1887, and, according to the reports which have been furnished me by the company, the results obtained up to the present have been very satisfactory from the standpoint of firmness of the seating of the track and from that of the expense of maintenance, which has been almost nothing since the substitution of these metallic ties for the wooden which were previously used.

LEAD-PENCILS.

All engineers use black lead-pencils, yet very few know precisely how they are made. They take them as a matter of course, and so long as they are good they care very little about where they come from or the manner of their production; and yet the manufacture of black lead—plumbago—pencils involves the use of ingenious if simple machinery, and presents many points of much interest. A short description of the

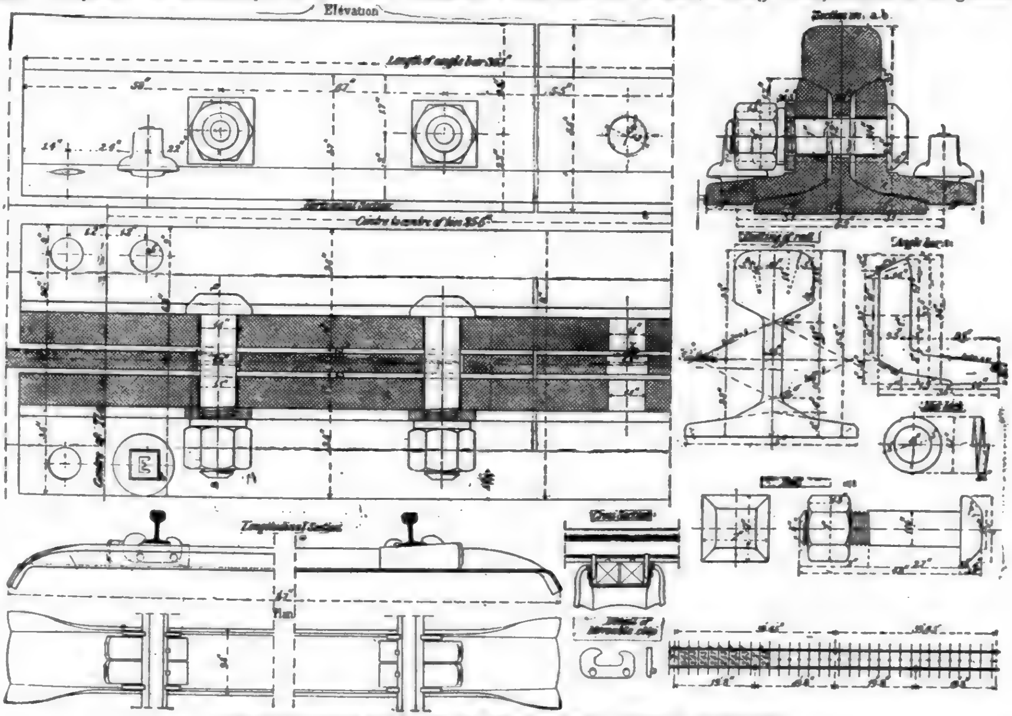
process as carried on in Cumberland in the present day will not be out of place in our pages.

When the first black lead-pencil was made is unknown. That is a secret locked up in the treasure house of history. In a book on fossils by one Conrad Gesner, of Zurich, written in the year 1565, reference is made to an article bearing strong resemblance to a black lead-pencil. About this date was discovered the famous Cumberland "lead" mine at Borrowdale, and in all probability Conrad Gesner referred to one of the first specimens made in that district. It has been asserted that a manuscript of the thirteenth century by Theophilus shows signs of having been ruled with black lead; but as the fact is not well established, we may accept the date of Gesner's book as the probable birth time of pencils.

It is said that plumbago was first found on the roads in Cumberland. The curious black stuff that made marks so easily attracted attention. It was searched for and found in stones used for making fences Cumberland fashion at the roadside. Then inquiry was pushed further, and finally the Borrowdale mine was opened The discovery of the mine was a source of considerable wealth to the owners, as the plumbago was found in such a pure state and in such large pieces that it had merely to be cut into long narrow bars by means of fine saws and be immediately mounted in wooden cases. The loss, of course, was exceedingly great, and as small specimens were practically useless, the surface lead was rapidly exhausted. The mine was pushed further, and certain curious restrictions were put on its working. Once a year it was opened for a short time, and as much taken out as would suffice to meet the demand. But these restrictions were useless; plumbago was found elsewhere, and it can now be imported from Ceylon and sold for less money than the Borrowdale lead costs. Indeed, it is doubtful if more than an insignificant quantity exists in Borrowdale. Next, as it had become evident that there was a great demand for lead-pencils, both on the Continent and in England, inventors sought to discover a means of solidifying the waste powder into lumps from which the bars could be cut. To Mr. Brockedon in England, and M. Conté in France, are due the honor of the discovery of the two methods which obtained. M. Conté's system is still in use, and indeed very soon after its publication superseded the English system.

Mr. Brockedon, having reduced the waste plumbago to a very fine powder, tried to conglomerate it into a solid homogeneous block by great pressure. All his attempts were frustrated by the breakdown of the machines under the required pressure. The air in the powder prevented cohesion. He then hit on the idea of conducting the same operation *in vacuo*. As it was found impossible to introduce the compressing machinery under the bell of the air-pump, he adopted the following ingenious method: The powdered graphite was formed into a cake under a moderate pressure; over its entire surface was then glued thin paper; in one side was pierced a small hole. The block was then introduced into the exhausting chamber, and all the air and moisture removed. While still in the vacuum the small hole was covered by an adhesive wafer. The block was withdrawn and subjected to a regulated pressure, and an artificial block of graphite was produced. A number of these blocks were then glued to a thin board. The larger block this formed was cut into thin sheets, which were passed to the "fitter." This operative had before him a number of grooved slips of cedar or juniper wood, prepared to form the body of the pencil. Into the groove he inserted the edge of one of the thin graphite sheets, which he then snapped off level with the surface, leaving a strip of lead in the groove. Another operative glued the other portion of the pencil to the first piece, thus completely encasing the lead. In succeeding operations the pencil was rounded and polished.

The method devised by M. Conté in 1795 of utilizing the waste plumbago obtains, as we have said, in the present day. The principle in brief is to mix intimately with the finely powdered mineral a certain proportion of a pure clay, or clay containing the smallest proportion of calcareous or silicious matter, which acts as binding and gives aggregation and solidity to the powder. The same system is employed for the formation of colored crayons, as well as for black lead-pencils. M. Conté prepared the clay on a gravitation principle. The clay coming from the pits was stirred for some time in a large quantity of water. It was then allowed to settle, and the supernatant milky liquid was drawn off by a siphon from near the clay surface into another vessel. This milky fluid was again allowed to settle and again the liquid drawn off, till a very fine clay only was deposited from the final drawing. This was then intimately mixed with a certain proportion of purified and calcined plumbago, on the quantity of clay depending the hardness of the pencil. M. Conté obtained admirable results with as much as three parts of clay to two of plumbago; a fine paste was thus produced. So far this system is used in the present time; the manufacture of the pen-

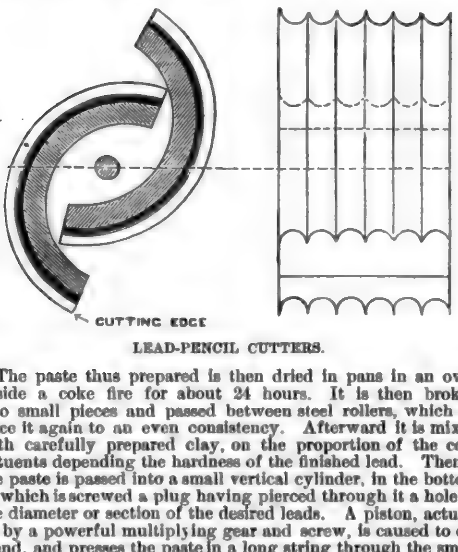


THE GUILLAUME TIE USED ON THE EASTERN RAILWAY OF FRANCE.

cils proper has been considerably modified. Before describing it we will, however, roughly sketch the old French method. The paste was now rubbed into grooves in a board, which was then covered by a flat board screwed firmly to the first, and the whole put aside to dry. This it did slowly, as only the ends of the sticks were exposed; but as they dried they shrunk, and allowed the air to reach the interior parts. When they were completely dry, the leads shook easily out of the grooves. They were then subjected to a very high heat, and afterward were ready for insertion in their wooden cases. By these two methods square leads only could be manufactured; but by employing round holes pierced in a metal block, through which the paste was pushed, instead of grooves in wood, M. Conté constructed round leads.

Not far from the Keswick railway station is situated the Greta Pencil Works of Messrs. Banks & Co. The river Greta passing under it supplies the building at once with a name and motive power. Two 12-ft. breast water-wheels, set at right angles to each other in the basement, drive the shafting by means of spur gearing. The establishment is not a large one—not more than about 50 hands finding employment there; among these are several women. It was established in 1832, and at that time was able to procure lead from the mines in the district. They are now, unfortunately, nearly exhausted, and plumbago has, as we have said, to be imported from Ceylon.

The first process, conducted in the lower part of the building, is to grind the material between French burrs; for fine leads this operation has to be continued from three to four weeks, the paste—water is employed—being returned over and over again, till it is judged to be of a sufficiently fine and even texture. The stones have to be frequently redressed, as the surfaces become highly polished.



LEAD-PENCIL CUTTERS.

The paste thus prepared is then dried in pans in an oven beside a coke fire for about 24 hours. It is then broken into small pieces and passed between steel rollers, which reduce it again to an even consistency. Afterward it is mixed with carefully prepared clay, on the proportion of the constituents depending the hardness of the finished lead. Thence the paste is passed into a small vertical cylinder, in the bottom of which is screwed a plug having pierced through it a hole of the diameter or section of the desired leads. A piston, actuated by a powerful multiplying gear and screw, is caused to descend, and presses the paste in a long string through the small orifice at the bottom of the cylinder. An operative breaks off lengths of about 2 ft. of this in his fingers, and arranges them in grooves in a horizontal board. If the finished leads are destined for use in pencil cases, the strings thus placed are cut off into the requisite lengths with a knife, on a board on which the different lengths are indicated by scratches. The leads are then allowed to dry naturally for some time, afterward they are roasted for a short period in the oven, and finally, packed on end in iron cases, are subjected to a very high temperature in a furnace. The leads for pencil cases are then put, a number at a time, into a "wobbling" tray, where they become highly polished by rubbing against each other. They have then only to be packed. The leads to be mounted in wood, omitting this polishing operation, pass to another department, where the operatives place them in grooves in slips of cedar wood. The wood being well glued first, then the leads, which are taken in small bundles between the thumb and fingers, and dipped first one end and then the other in boiling glue, the surplus of the mucilage being rubbed off with the other hand, are laid in place, and a similar grooved or flat slip of cedar—depending on the section of the lead, as will be explained later—is placed on the first. These slips are then clamped, a number at a time, in iron frames, and placed aside to dry.

We must now look back at the manufacture of the grooved slips. The cedar is reduced by circular saws from the balks in which it is received into small pieces of short length, and presenting a section sufficient to make 24 complete pencils of the ordinary size; six pencils to be cut out of the width. These blocks are again cut into thin slips by a circular saw. On one side of each slip along its whole length is cut by small circular saw a narrow groove at a certain distance from one edge; this groove serves as a guide through succeeding operations. The opposite side is then planed by a rotating cutter, and six grooves cut down its length by saws. If the case is for square leads, the grooves thus cut are of square section; if for round leads, of semicircular section. These are the slips that then pass to the gluing-up room, and for the square leads are covered by thinner slips, and for the round by a similar grooved piece.

When the glue has thoroughly set, the slips pass to the rounding machine. This machine is of very simple construction. The tool consists of two semicircular pieces of steel, in diameter perhaps 4 in., which are set eccentrically on a spindle rotating at a high speed. The accompanying sketch will give an idea of the tool. In the periphery of these pieces are formed grooves, presenting half the circumference of a pencil section. The operation is evident. The slips, fed one after another along a steel table under the tool, are first corrugated on one side; the operation being repeated on the other side, six circular sticks are produced at once. The succeeding operations are then cutting to length, sand-papering, and polishing, which are done by hand, four or five pencils being in treatment at a time, stamping the maker's name, etc. When this is to be done in gold, a woman rubs some bronze powder with a brush over the part to be stamped, a die actuated by a screw is then caused to descend on the pencil and impresses the letters; a row of small gas jets on each side of the machine slightly warms the die, which melts the varnish and causes the gold to adhere; the waste powder is rubbed off with a cloth.

On common pencils—joiners', etc.—where the name is not gilt, an apparatus is used which performs the operation instantaneously. It consists merely of two small wheels, one above the other in the same plane. The lower one is grooved to guide the pencil, and rotates. Around a portion of the periphery of the upper one are cut the letters to be stamped. On the spindle of this one is a small crank, which, in connection with a spring and cord, always pulls the disk back to its starting position. A spring also presses the upper wheel toward the lower, but not to touch it. The pencil end being inserted between the two, the pencil is at once snapped in, stamped, and ejected into a drawer placed to receive it.

Since the supply of Cumberland lead has failed it has become exceedingly difficult to make small establishments in this district pay, especially when they have to face not only an internal competition, but a foreign also, from such houses as Johann Faber's, of Nuremberg. This famous house was established in 1761. In 1885, we believe we are right in saying, there were engaged directly and indirectly in that business on the Continent 5,000 persons, turning out pencils at the rate of 250,000,000 annually, a quantity worth about $20,000,000.

It may be interesting to know that all the waste from the Keswick establishment is sent to Aberdeen, where it is employed in the manufacture of rough felt. This waste consists not only of outer shavings and sawdust, but of pieces of pencils which are rejected as being unsound on account of knots and defects in the wood. The felt is used principally for laying under carpets, the pleasant smell of the cedar rendering the felt popular.—*Engineer.*

PRACTICAL TRAINING OF STATE ENGINEERS IN WURTEMBERG.

THE practical training of engineers who intend to join the service of a State railway or other State concern has of late years been the object of serious consideration in Germany. It does not appear that universities and higher technical schools have been able to give anything like a training sufficiently practical for the requirements of the Public Works Departments, and this has led the Prussian State, and more recently that of Wurtemberg, to issue special prescriptions on this important matter.

The decisions arrived at refer both to civil and mechanical engineers. We will examine more especially the principal features of the prescriptions of the State of Wurtemberg relating to the training of mechanical engineers who wish to enter the service of the State.

These came in force on June 1, 1893, and were issued by the Minister of Foreign Affairs conjointly with the Ministers for Education and Finance.

Mechanical engineers intending to join the service of the State must have had three years' practical experience in an establishment belonging to the State. These three years comprise: 1. A year's practical work in a workshop previous to the passing of the first State examination in mathematical and physical sciences. 2. After the passing of this first State examination, two years' work in the supervision, accounts, stores and other departments connected with the State workshops; the greater part of this second period is spent in the study and designing of new machinery, and also in assisting the higher officials, or in the management of the works.

Those who wish to join the railway service must serve three months on a locomotive engine, and at the end of that time must be able to show that they can drive locomotives and trains.

The time spent in the supervision and accounts of a workshop must be six months. That spent in the designing of machinery and mechanical installations must be at least twelve months. The duration of the candidate's employment in an administration, or in the managing office of works, shall be at least three months. It will be understood that these various stages of the training have for their purpose to familiarize the candidate with practical work, and he is not to be employed in any responsible capacity unless circumstances absolutely justify it.

The work done in the shop has for its purpose to enable the candidate to acquire a practical knowledge of the branch he intends to select. He must acquire skill in the manipulation of the various tools, so as to be able to manufacture, himself, the engine parts, and get acquainted with the difficult points of the execution of the same.

Great stress is laid upon a sound knowledge of materials and their behavior when they are being worked upon, on the use of machine tools, the forms of engine parts, and the constructive development of the same. In this respect it is advisable that some time should be spent in the foundry and pattern shop.

The time spent in the workshop will enable the candidate to become acquainted with workmen and the conditions under which they have to work. It will also enable him to form a judgment about them and to learn how to treat them.

The time spent in the fitting shop must be six months at least; that in the foundry, two months. If the candidate has already some knowledge of pattern making, he need not spend more than a month in the foundry. A month or two must be spent in the smithy and in the lathe shops.

No remuneration is given to the candidate who is undergoing, in a State concern, the first year of his practical training. The first year over, the candidate is then entitled to sit for the first State examination. It will be noted that the time specified in the above looks somewhat too short; but it must be remembered that the thorough technical education already acquired in the higher schools, previous to entering the workshops, is sure to prove of valuable assistance to the candidate when he enters the workshops.

The length of these various stages must naturally depend upon the career which the candidate intends to follow. It is the intention of the legislature that the education of the future engineer should be of a more specialized nature than that previously obtained in the university or higher technical school. Those who intend to enter the carriage department need not go into the locomotive erecting shop, but devote most of their time to the practical study of that particular branch of rolling stock manufacture. This is all the more wise, as we know that a good locomotive engineer seldom makes a good carriage superintendent. We have already mentioned that those who have selected the career of locomotive engineer have to serve three months on an engine; the usual driver's examination is, however, in this case, limited to the driving of engines; for the candidate is supposed to know all about the working and construction of locomotives. A certificate stating that the candidate has acquired the necessary knowledge to drive an engine is duly delivered to him upon the completion of the period. During the six months' service spent in the managing and account department of a workshop, the candidate must be under the supervision of the workshop manager or director. The latter must impart to him all the necessary knowledge concerning the duties and responsibilities of the foreman of such a State workshop. The young engineer must be placed in a position to form an idea of the capacity of the workshop and its appliances, of the abilities of the operatives, and the quantity of work they can individually turn out. He will further have to take part in the inspection and testing of new or repaired engines, carriages, etc. The keeping of workshop accounts must also be explained to him, so that he may be able for a short time to undertake the duties, or assist the foreman of a small department; but the latter test should not occupy more than the last three months of the first stage of the second period of practical training. A certificate will then be delivered to the candidate, stating how the time has been spent, and in what works. It will also state what amount of practical knowledge has been obtained during that time.

Then comes a period of at least twelve months to be spent in the designing of engines and mechanical installations. The candidate will be entrusted more particularly with the preparation of working drawings for the department or branch he has selected.

Three months may be spent in the inspection and reception of the materials at the works, which are supplied by contractors or others to the State railway or other department, where the candidate is undergoing his two last years of practical training.

The greater portion of the twelve months must, however, be spent in the designing of machinery and mechanical installations. The three months spent in an administration have for their purpose to familiarize the young engineer with the working, attributions of the administration, and their management of the whole concern. Some time must be spent in the registering, secretary's, and revising offices. The drawing up of specifications, contracts, and agreements, must be rendered familiar to the candidate. The administration deliver a certificate as to the time spent in their offices.

During this second part of his practical training the young engineer receives a salary commensurate with the services he is able to render, and the regulations in force. But no salary is paid to him during the time spent in the administration, unless he is entrusted with special work requiring a special staff.

This completes the three years' practical training, and the candidate can sit for the final State examination, which, if successfully passed, qualifies him for the post of government engineer. The practical training may take place in private concerns; but certain formalities and prescriptions have to be fulfilled before the certificates delivered by such concerns entitle the candidate to pass the first and second State examinations.

It must not be thought that the granting of these certificates, and the successful passing of the final State examination are for the object of putting at the heads of various State departments comparatively inexperienced young men. The successful students are simply entitled to a responsible position in the State services which require a superior education and technical knowledge. They have to work their way up in the usual manner.—*Railway Herald.*

TRIAL OF SCHNEIDER'S NICKEL-STEEL ARMOR FOR RUSSIA.

An excellent statement of the conditions of a recent trial of nickel-steel armor, at Creusot, for the new Russian battleship *Tria Sviatitelia* (Three Saints) appeared in the *Times* of September 9, 1893. The plate measured 8 ft. × 8 ft. × 15.9 in. It, therefore, probably weighed nearly 18½ tons. The conditions of acceptance were that it should receive four blows from Holtzer projectiles of chrome steel, weighing 317 lbs. each, fired from a 9.4-in. gun, with a striking velocity of 1,945 foot-seconds, without any portion of the plate being broken off, while in no case should the "*base* of the projectile" enter 7.8 in., measured from the face. The exact words used are "penetrate the target to a depth of as much as 7.8 in." The four rounds were delivered at the corners of an imaginary square of 4 ft. sides.

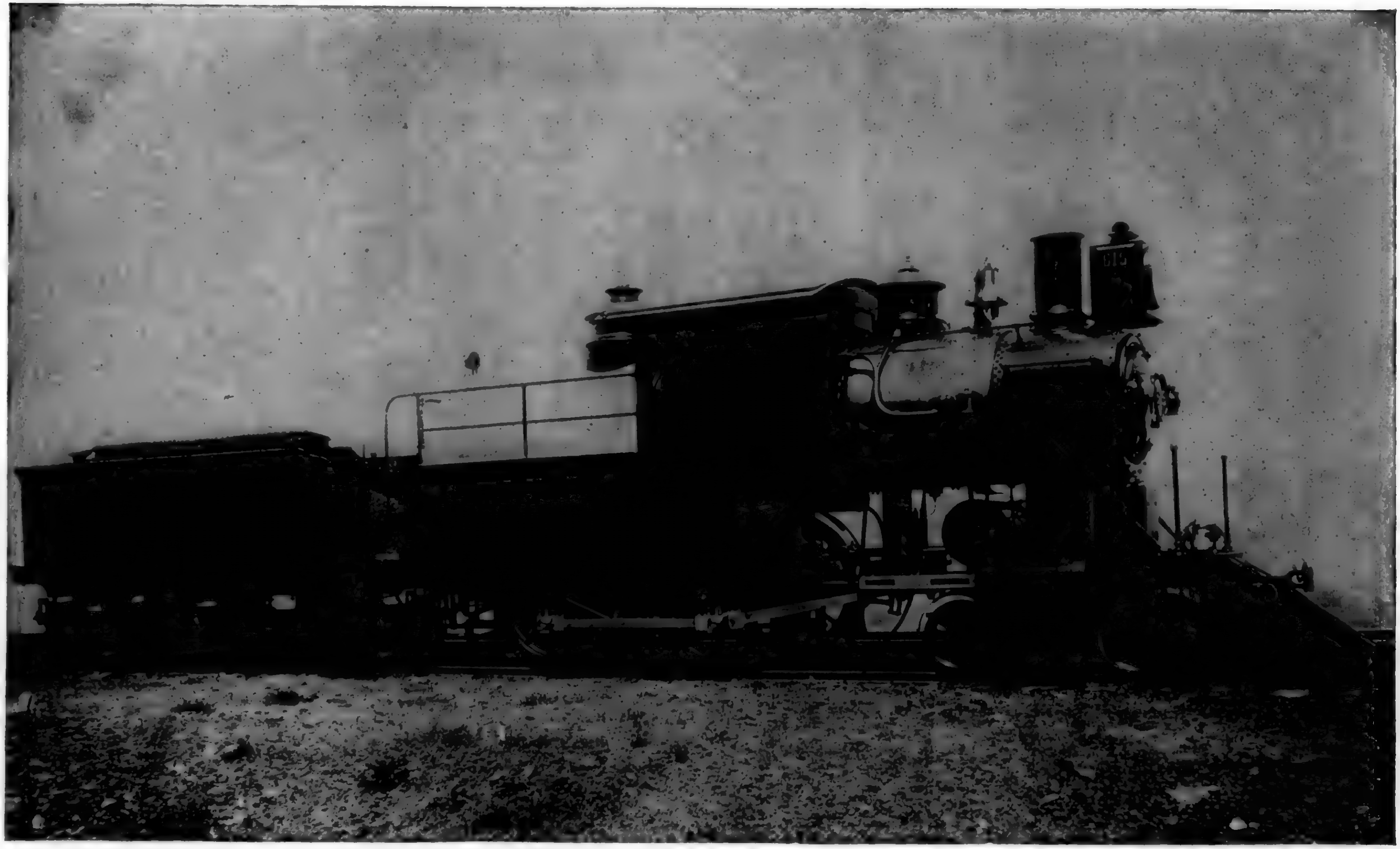
Round 1: Had a velocity of 2,001 foot-seconds; the shot's point entered 14.1 in., and the projectile rebounded "with the point smashed, and the shoulder somewhat set up." "The target showed three very fine cracks running from the wound."

Round 2: Striking velocity, 1,948 foot-seconds; penetration of point, 10.9 in. The projectile rebounded, broken into numerous fragments. Three fine cracks, as before, were developed in the plate.

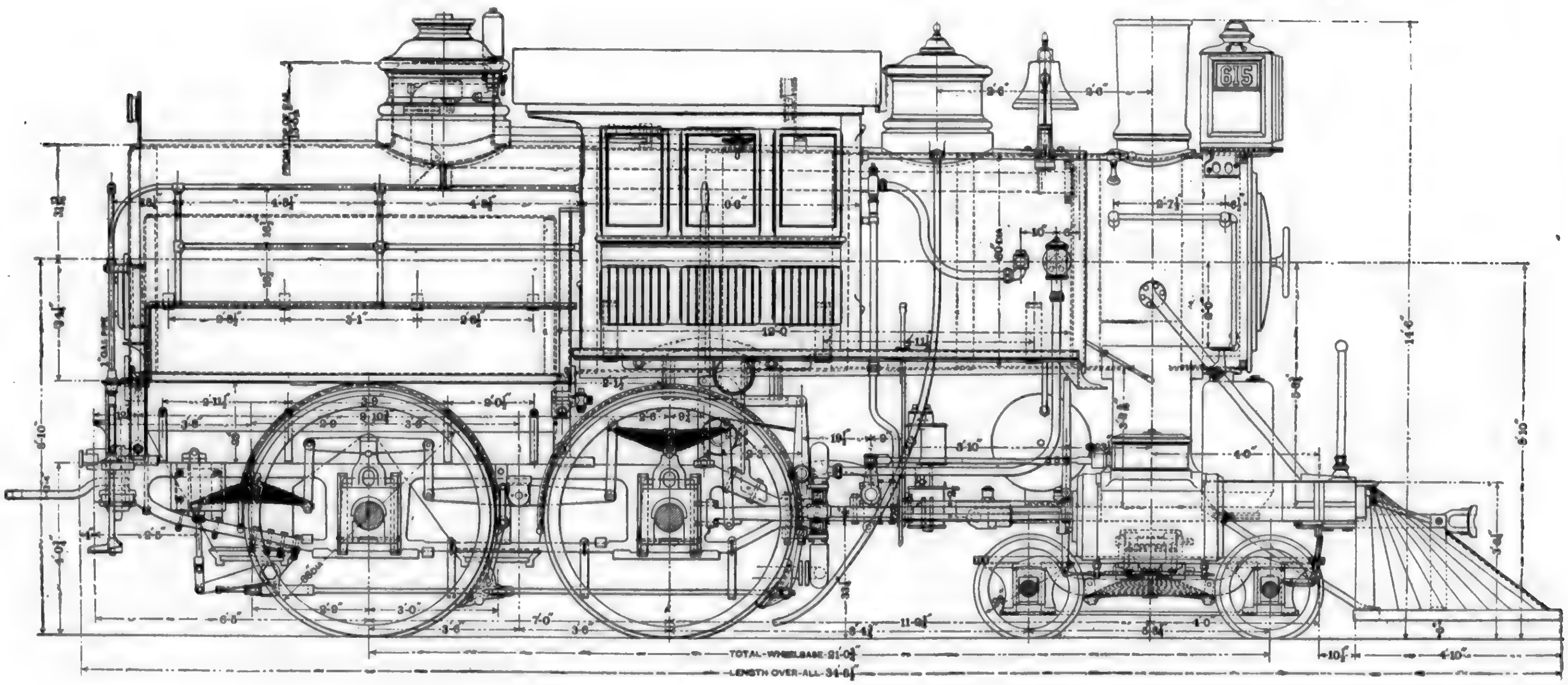
Round 3: Striking velocity, 1,923 foot-seconds; penetration of point, 14 in. The projectile rebounded with the head smashed, and the cylindrical part somewhat set up. A single fine crack was developed.

Round 4: Striking velocity, 1,962 foot-seconds; penetration of point, 9.9 in. The projectile rebounded, broken into numerous fragments. There were no fresh cracks, and the old ones were not increased.

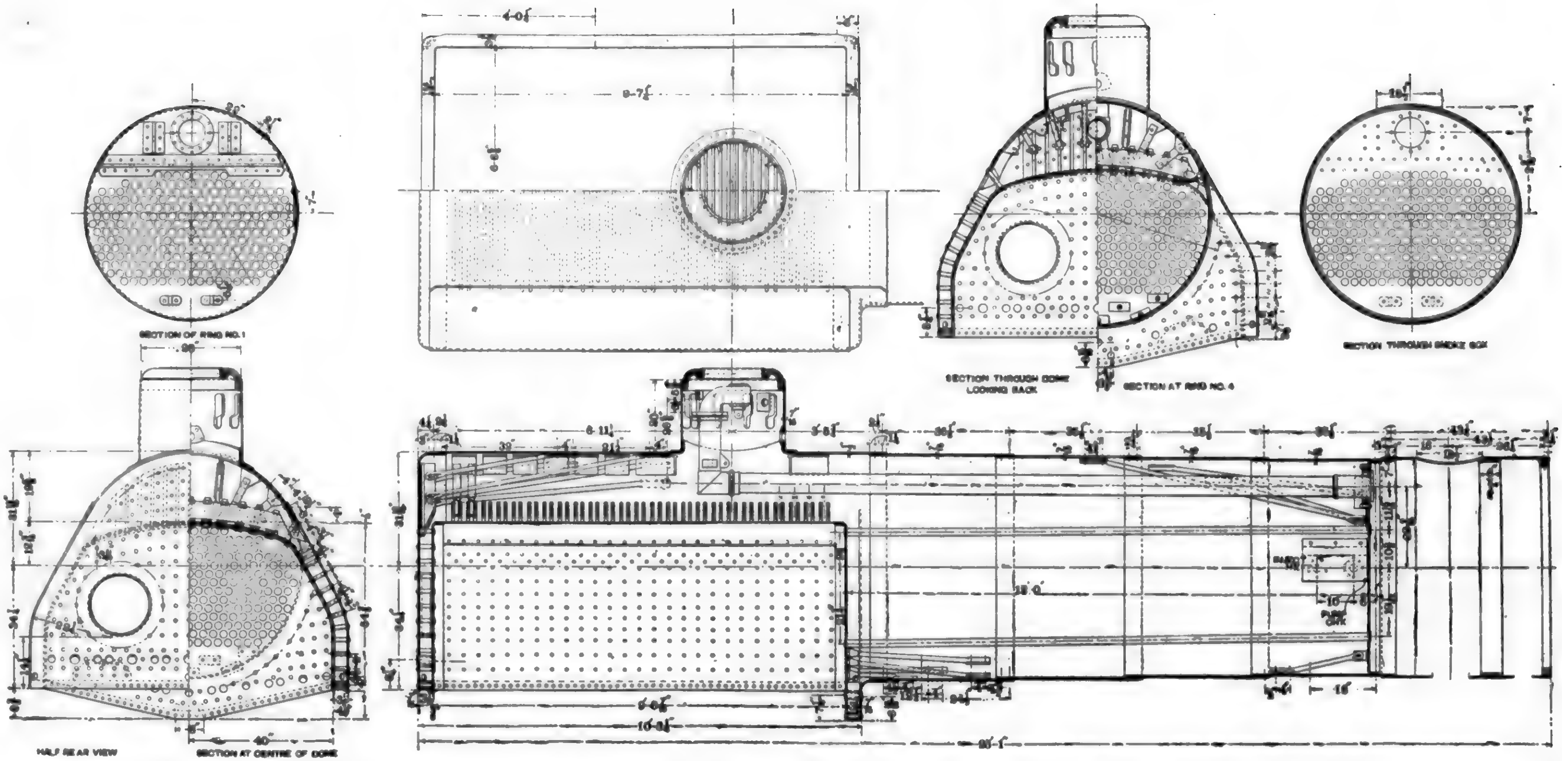
At the back the bulges behind the points of impact varied from 1 in. to 1.7 in. high. Behind 1 and 2 were some fine cracks.



EXPRESS PASSENGER LOCOMOTIVE, BUILT BY THE LEHIGH VALLEY RAILROAD AT SOUTH EASTON, PA., JOHN I. KINSEY, M.M.



SIDE ELEVATION OF EXPRESS PASSENGER LOCOMOTIVE, BUILT AT THE SOUTH EASTON, PA., SHOPS OF THE LEHIGH VALLEY RAILROAD; JOHN I. KINSEY, M.M.



BOILER FOR EXPRESS PASSENGER LOCOMOTIVE, BUILT BY THE LEHIGH VALLEY RAILROAD, AT SOUTH EASTON, PA.

We presume that this plate passed the test. To Messrs. Schneider is the credit due of having first applied nickel to the manufacture of armor, and having been long the sole manufacturers of through steel armor, which is now universally approved. Rare indeed is it for Messrs. Schneider to make a bad plate, and this plate is a very good one indeed. Messrs. Holtzer's projectiles have long been taken as the standard of highest excellence. These facts being so, it is interesting to compare the above trial with recent American and English results. In a trial which took place at Indian Head on July 11, 1893, a Bethlehem all steel nickel plate, 17 in. thick, was attacked by a 12-in. gun, firing forged steel Carpenter projectiles with varying velocities. The second round most nearly corresponded to the results now before us. The velocity was much lower—namely, 1,495 foot-seconds; but the theoretical penetration and the shock per ton were not so much less as to prevent comparison. On the English system the theoretical conditions are as follows: Schneider plate, third round, theoretical perforation through iron 17.36 in., the plate being 15.9 in. thick. Bethlehem plate, second round, theoretical perforation 19.18 in., the plate being 17 in. thick. The energies per ton of plate were respectively 483 and 425 foot-tons. The Schneider plate was therefore more severely tried as to fracture, and it may be noted that it exhibited a slight hair crack. The shot entered much more deeply in the Bethlehem, which, we think, was decidedly softer than Schneider's; undoubtedly both plates were excellent. To come to the projectiles, it can hardly escape observation that Holtzer's larger projectiles do not behave as well as those for his 6-in. gun. It may be well expecting a good deal to ask that 9.4-in. projectiles should rebound intact after impact at over 1,900 ft. velocity on steel, although the 6-in. projectiles will often do this. The Carpenter 12-in. projectiles rebounded apparently uninjured from the Bethlehem plate at, after striking, 1,838 ft. velocity. It may be urged that the Bethlehem plate was rather softer, and at this velocity it was overmatched. Still, making all allowance, the fact remains that, putting fracture aside, the Holtzer 8-in. projectiles at Indian Head, America, have been regularly and symmetrically setting up, and here, on this occasion, the 9.4-in. projectiles in two cases set up as well as breaking up. A projectile ought not to set up under any circumstances. Consequently, we think that Holtzer's larger projectiles cannot at present claim at all the high character that the 6-in. ones have maintained.—*The Engineer.*

EXPRESS PASSENGER ENGINE FOR LEHIGH VALLEY RAILROAD.

The engine which we illustrate with a full-page, half-tone, and other engravings, is one which was designed and built some time since by Mr. John I. Kinsey, Master Mechanic of the Lehigh Valley Railroad at the South Easton shops. The general outline of the engine is one which has become very familiar to those who are in the habit of traveling over the anthracite roads of Eastern Pennsylvania, where the cab is located well to the front over the forward driving-wheels. In this position of the cab the engine rides remarkably easily, and is well adapted for fast running. In this engine, as in all of the other engines of the Lehigh Valley Road, anthracite coal is the fuel used. The engine was employed for some time by the Philadelphia & Reading Railroad, in hauling their fast express trains of the Royal Blue Line from Jersey City to Philadelphia, and gave remarkably good results, in that there was no difficulty with hot journals and insufficient generation of steam, the engine hauling the trains at various speeds ranging from 55 to 75 miles per hour between stations.

Below we give a list of the general dimensions of the engine:

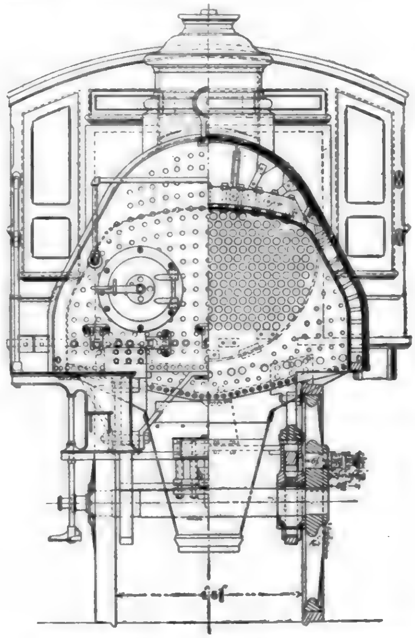
Gauge of road	4 ft. 8½ in.
Total weight of engine in working order	108.640 lbs.
Weight on driving wheels	77,616 lbs.
Weight on truck	31,024 lbs.
Total wheel-base	21 ft. ¾ in.
Distance between centers of driving-wheels	7 ft.
Length of main connecting-rod center to center	7 ft. 3 in.
Transverse distance from center to center of cylinders	6 ft. ¾ in.

CYLINDERS, VALVE, ETC.

Diameter of cylinders	19 in.
Stroke of piston	26 in.
Diameter of piston-rod	3½ in.

WHEELS, ETC.

Diameter of driving-wheels outside of tires	5 ft. 8 in.
Diameter of truck wheels	28 in.
Driving axle journal	7½ in. diam., 8 in. long.
Size of truck axle	4¼ in. diam., 6¼ in. long.
Size of main crank pin journal	4½ in. diam., 2¾ in. long.
Size of coupling-rod journals	3¼ in. diam., 3¾ in. long.
Length of driver-springs from center to center of hangers	2 ft. 8 in.



REAR ELEVATION. CROSS-SECTION THROUGH MAIN DRIVING AXLE.

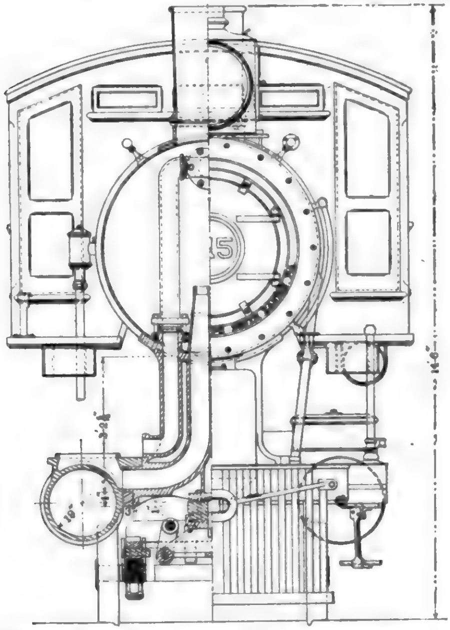
EXPRESS PASSENGER LOCOMOTIVE, LEHIGH VALLEY R. R.

BOILER.

General description	Straight top.
Inside diameter of smallest boiler ring	50¼ in.
Material of barrel and boiler	Steel.
Thickness of plates in barrel of boiler	$\frac{7}{16}$ in.
Kind of horizontal seams	Lap, double riveted.
Kind of circumferential seams	Double riveted.
Material of tubes	Iron.
Number of tubes	263.
Diameter of tubes outside	2 in.
Distance from center to center of tubes	2¾ in.
Length of tubes over tube plates	12 ft. 1 in.
Length of fire-box	9 ft. 6$\frac{7}{16}$ in.
Width of fire-box	6 ft. 8 in.
Maximum depth of fire-box	54⅞ in.
Water space around fire-box	3½ in.
Thickness of plates inside of fire-box	$\frac{5}{16}$ in.
Thickness of plate back end of fire-box	⅜ in.
Thickness of crown plate	$\frac{7}{16}$ in.
Thickness of tube plates	½ in.
Method of staying crown sheet	Crown bars.
Inside diameter of dome	28 in.
Height of dome	20 in.
Kind of grate	Water bars and removable shaking bars.
Total heating surface	1,575.92 sq. ft.
Kind of exhaust nozzle	Double.
Diameter of exhaust nozzle	3⅜ in.
Smallest inside diameter of stack	17½ in.
Height from top of rails to top of stack	14 ft. 6 in.
Height top of rails to center of boiler	8 ft 10 in.
Grate area	63.61 sq. ft.

It will be noticed that in the arrangement of the tubes they are placed in horizontal lines rather than vertical, which is in

accordance with the older methods of tube arrangements, but which has been varied by other designers of late years, although it is the same as that which is used by Mr. Buchanan in the engine which we illustrate of English and American locomotives. The general appearance of the Wootten fire-box has been retained, and the staying of the sheets has been accomplished in the usual manner of running braces back to the shell. Stays are dropped down also from the side of the shell of the dome to the crown bars. The outside shell of the fire-box, which comes opposite the seams and opens at the upper end of the inside shell, is braced by angle plates riveted on, and the stay-bolt for the crown sheet is thrown out so that it enters the crown sheet nearly square, and runs into the outer



CROSS-SECTION THROUGH CYLINDERS. FRONT ELEVATION.

EXPRESS PASSENGER LOCOMOTIVE, LEHIGH VALLEY R. R.

sheet of the fire-box at a considerable angle. The spacing between the stay-plates at the outer shell at this point is 7⅜ in. This point is also stayed by a connection between the angle plate, which is riveted to the outside shell, and the crown bars, as shown in the cross-section of the boiler.

The mud ring is planed off on the corners so that there is a smooth lap for the outside sheet of the fire-box, and the trouble of making a tight joint at this point is to a great extent overcome, although it requires very careful fitting of the sheet that it and the planed-off portion should fit. The forward tube sheet is stayed above the tubes by angle plates riveted across, as shown in the end elevation, and braces running back to the shell, as already described. There are 10 water grates, each 9 ft. 9 in. long, and the crown bars are 4½ × 3½ in., varying in length from 50 to 62 in.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 483.*)

Having thus designed and built his apparatus, the next point for M. *Maxim* to consider was how to get it up into the air, how to control it while sailing, and how to alight with it safely. To this he has evidently given much thought, and in an article published by him in the *Cosmopolitan Magazine* for June, 1892, he thus describes what course he would pursue if a sum of $100,000 were placed at his disposal, for constructing and experimenting a successful flying machine; which course seems to be so carefully planned that we may fairly assume that it is the one determined upon by M. *Maxim* for experiments with his own actual machine.

The machine should be run around the one mile track at all speeds, from 20 miles per hour to 100 miles per hour, and the power actually required should be carefully noted. These runs would enable us to ascertain how our pumps worked at high speed, and how much our screws pushed, and if we put a brake to the wheels we should find out the slip of the screws. We could also ascertain the efficiency of our condenser at various speeds, and the temperature of the water could be taken. In order to run on a railway track, the machine, of course, must be provided with wheels, and two sets of these would be necessary; one set should be of great weight, so as to hold the machine down when running on the track, and the other set should be light, for actual flying. Springs should be interposed between the axletrees and the machine, after the manner of railway carriages, and there should be attached above each wheel some sort of an index or indicator to show the exact load resting on each wheel. When all the parts of the machine had been made to operate smoothly and satisfactorily, the silk could be placed on the aeroplanes, and then our serious experiments might be said to commence.

We should first begin by running slowly—say at the rate of 20 miles per hour—and carefully note the lift on the indexes over each wheel. If we found that with a speed of 20 miles an hour, three fourths of the load was lifted off the forward axletree, and only one-fourth off the hind one, then we should change the center of weight further forward, so as to bring it as near as possible under the center of effort or lift. We should then make another trial, and if we found that the lift was equal both fore and aft, we should increase the speed very carefully, gradually observing the lift at the four corners of the machine, until the whole weight of the machine was supported by the aeroplane, and the whole weight of the wheels (about one ton) by the railway track. Then, when there was neither lift nor load on either wheel, we might consider that we had arrived at a stage in our experiments where we could turn our attention to the subject of steering.

A boat has to be steered in only one direction—namely, a horizontal direction, to the right or to the left. A locomotive torpedo or a flying machine must be steered in two directions—right or left, or up or down. We should experiment with the more difficult one at first—namely, the up and down or vertical direction. We should attach two long arms to our aeroplane in such a manner that they would project a considerable distance in the rear of the machine. To these arms we should pivot a very large and light silk-covered rudder and connect it with ropes, so that it could be turned up or down by a small windlass from the machine. We should then take a run on the track and see if the changing the angle of this rudder would increase or diminish the load on the forward or hind wheels. If we found that it would do this, but not sufficiently so, we should attach another rudder in exactly the same manner to the forward end of the machine. Suppose that, at a speed of 35 miles per hour, with both rudders set at the same angle as the aeroplane, we should find that the whole weight of the machine was carried by the aeroplane and the whole weight of the wheels (2,000 lbs.) by the track, we could then consider that the adjustment of our load was correct, and that the center of weight was directly under the center of effort for a speed of 35 miles an hour. We should then elevate the front edge of the forward rudder and depress the front edge of the rear rudder; this would cause the machine to lift on the forward axletree and the rear end of the machine to press on the hind axletree. If we found by changing the angle of the rudders that the load could be increased or diminished on either axletree to the extent of 15 per cent. of our whole load, we could consider that this phase of the problem was solved.

For horizontal steering we should try first the effect of the screws. There should be a three-way valve in the steam pipe connected with a lever, so that we should be able to partly close off the steam from the engine of one screw, and turn more steam on to the other. This would probably be all that would be found necessary; if not, we should try rudders.

To prevent the machine from swaying in the air, the aeroplane should so be constructed that no matter in which direction it tilted it would diminish the lifting power of the lifted part and increase the lifting power of the depressed part. This (diedral side wings) would be simple and automatic; moreover, the stability of the machine could be still further increased by having the center of gravity much below the center of lift.

Having all things in readiness, the heavy wheels should be removed and the light ones put on; and taking one man with

us to attend to the two horizontal rudders and to keep the machine on an even keel,* we should take our first fly, running the engines and doing the right and left steering ourselves. A day should be selected when there was a fresh breeze of about 10 miles per hour. We should first travel slowly around the circular railway until we came near that part of the track in which we should face the wind. The speed should then be increased until it attained a velocity of 38 or 40 miles an hour. This would lift the machine off the track and probably would slightly change the center of effort. This, however, would be quickly corrected by the man at the wheel. While the machine was still in the air careful experiments should be tried in regard to the action of the rudders; it should be ascertained to what degree they had to be tilted in order to produce the desired effect on the machine. The machine should also be run at a speed less than 35 miles per hour in order to allow it to approach the earth gradually; then the speed should be increased again to more than 35 miles an hour in order to rise, at the same time trying the effect of running one propeller faster than the other, to ascertain to what extent this would have to be done in order to cause the machine to turn to the right or to the left. If the machine should be constructed so that each particular foot of its surface carried a load of 1 lb. 3 oz., and if we should stop the engine dead and allow the machine to fall, it would approach the earth at a speed of 15 miles an hour, or one mile in four minutes. This evidently would cause a considerable shock, and unless there was a good deal of elasticity to the parts and a good deal of travel between the axletrees and the machine, the shock would probably be sufficient to distort or injure some part of the light structure. But it is not necessary to approach the earth directly. Professor *Langley* found in his experiments that when a horizontal plane was travelling rapidly through the air, it approached the earth as though it were "settling through jelly."

A large field as near our railway as possible should be selected for alighting, and having approached the field so as to be facing the wind, we should gradually descend by slowing up the engines, and finally alight while the machine was still advancing at the rate of 20 miles an hour. If the wind should be blowing at the rate of 10 miles an hour the machine would approach the earth very gradually indeed, so that all shock would be avoided. It would only require a few yards of comparatively smooth ground to run on after alighting, in order that there should be no disagreeable shock or danger.

The cost of these experiments would be from $50,000 to $100,000, and the time required would be two years.

It will be noted how complicated and delicate these various adjustments must necessarily be, and how many different parts must be made to do their work perfectly before it can be safe to venture into the air. The aeroplane surfaces must be prevented from altering their shapes at varying speeds, the rudders must be made to maintain the course automatically, the engine must be governed as to speed, the boiler and gas jet flames must be regulated by the consumption of steam, and the condenser must be efficient at all temperatures of the air, as well as at all speeds. Moreover, and most important, no part must break under varying strains, and the equipoise must be maintained.

These are formidable and yet indispensable requirements, well calculated to appall the boldest inventor; for while with an experimental model an accident is of little consequence and is easily repaired, with an actual flying machine an accident will probably prove disastrous, even if the inventor does not lose his life.

M. *Maxim*, therefore, has acted most wisely in taking plenty of time and in testing his apparatus in every way before venturing to leave the ground with it. Having completed it so that it was ready for the hazard of actual trial, he next experimented with it under conditions of comparative safety, and opened up the chapter of accidents.

The first difficulty he met with occurred through the breaking of some of the wire stays. These had been made of steel high in carbon in order to secure great tensile strength, and they proved brittle. From a private letter from M. *Maxim*, dated October 6th, 1892, the writer is permitted to give the following extract, which gives also a most interesting and hitherto unpublished description of the steam-engine and boiler, which constitute thus far the great achievement of M. *Maxim*:

The steam generator is constructed somewhat on the Thorneycroft principle, except that the tubes are much lighter and thinner and have a greater number of sinuosities in them. In the Thorneycroft boiler the distributing water tubes at the bottom are of considerable size and of great weight. In my engine they are only 2¼ in. in diameter and 1¼ mm. in thickness. The downtake for the water is only 3 in. in diameter, and instead of having two, as with the Thorneycroft boiler, there is one, which branches off like the inverted letter Y. In the Thorneycroft boiler the difference in gravity of the water in the hot interior tubes and in the two external ones, which are not heated, is the only means of keeping up the circulation; but as all the passage-ways for water are very large, this is sufficient.

Suppose that in my system I am using steam at 300 lbs. pressure to the square inch; I have my water at a pressure of 335 lbs. to the square inch, and the water escapes through a species of automatic injector, and in falling 35 lbs. in pressure does a certain amount of work on the surrounding water. The cold water going in from the pump is therefore made to combine with the hot water in the downtake. This increases the gravity of the water and at the same time causes a very rapid forced circulation. No matter to what extent the fire may be forced, the water has to go through in any event. All the water that is coming in from the pump, as well as all of the water that it takes along with it from the top separating drum, from which the steam is taken, is forced through the hot tubes. The nozzle through which the incoming water escapes from the higher to the lower pressure is provided with a spring, which always keeps a difference in pressure of about 35 lbs.; whether the quantity of water pressing in is large or small, the difference is always the same. A very convenient apparatus is attached to the feed water pipe, by which it is possible to see at a glance exactly how many pounds of water per hour are entering the boiler. Directly over the boiler proper there is another series of very small copper tubes through which the water passes before entering the boiler proper, therefore products of combustion, after passing between the tubes of the boiler, are brought in contact with the incoming water before escaping. This so reduces the temperature of the escaping products of combustion that Brunswick black or linseed-oil are not burned off the smoke-stack.

For a fuel I employ naphtha of 72° Beaumé. This naphtha is pumped into a small vertical boiler heated with a part of its own contents.

The vapors from the boiler are led directly to an air injector, where they escape under a pressure of 35 lbs. to the square inch. The mixture of air and gas is then burned through rather more than 6,000 gas jets under the boiler. Steam might be also mixed if required. The distributing of the flame is very even, and it is possible to fill the whole fire-box with a purple flame. The regulating of the supply of naphtha is controlled by the weight of the gas generator; if the weight of the generator is too great, it operates upon a ratchet, which shortens the stroke of the pump; if it is too light, a spring raises the generator and its contents, when the ratchet operates in a contrary direction and increases the stroke of the pump. In this way the quantity of naphtha in the boiler is kept constant. The fire is regulated not only by the pressure in the boiler, but by a thermostatic regulator also. The feed-water pump is also regulated by changing the length of the stroke.

The engines are compound, and have a peculiar arrangement placed in a connection between the high and low-pressure cylinders in such a manner that if the pressure in the boiler rises above 300 lbs. to the square inch the steam is shunted past the high-pressure cylinder and enters the low-pressure cylinder, and it is arranged in such a manner that the pressure of steam falling from 300 lbs. to 100 lbs. does a certain amount of work on the exhaust steam that is passing through the high-pressure cylinder after the manner of an injector—that is to say, the escaping force of the steam reduces the back pressure on the high-pressure cylinder and increases the pressure on the low-pressure piston.

With two screws, each 17 ft. 10 in. in diameter, and with 300 lbs. pressure to the square inch, the machine has been made to pull on a dynamometer 1,960 lbs. If we multiply this pull by the number of turns per minute that the engine makes, and by the pitch of the screws, we find that the engines develop 300 horse power.

The complete weight of engines, boilers, pumps, generators, condensers, and the weight of water in the complete circulation, amounts to 8 lbs. to the horse power, and this of itself I consider quite an achievement.

The spread of the wings of the machine is 107 ft., and the total length from the point of the forward rudder to the rear end of the after rudder is about 200 ft. Beneath the main aeroplane there is a considerable number of narrow planes superposed, which extend outward to nearly the full width of the machine. So far, trials have only commenced with the main aeroplane, which is 50 ft. wide and 45 ft. long in the direction of the length of the machine.

The whole machine is mounted on steel wheels 8-ft. gauge, and springs are interposed between the machine and the axletrees; both forward and back axletrees are attached to a dyna-

* M. *Maxim* has since added the gyrostat.

graph, which makes a diagram of the lift of the machine as it advances upon the track. The drum which holds the paper turns once round in 1,800 ft., and whatever the machine lifts either forward or back is recorded upon the paper drum. One of the drums is also provided with a pencil, which makes a diagram of the speed at which the machine is traveling.

I am very much hampered, however, for room; there is very little clear space between the trees, and to obtain adjoining premises without trees costs a prohibitive sum. What I should have is a circular or oval track, which would be a mile long. When the experiments are tried with a side wind blowing five miles an hour, a lift of one ton has been recorded on one side of the machine, while the other side would not lift over 100 lbs.

The whole machine, when loaded, will weigh about 7,000 lbs., so you will see if the machine will lift anything like as much, per pound of push, as I succeeded in lifting with my first apparatus, it will be sure to go.

However, I find that a great number of steel stays are necessary in order to hold the machine in shape, and while these do not weigh much, they appear to offer a considerable resistance to the passage of the machine through the air. If I were to build another machine I should aim more at getting less atmospheric resistance, because I can see now that everything else is assured except this single factor. If the machine does not go it will simply be because too much force is expended in driving the framework through the air.

Work has been greatly delayed, in the first place, because I was absent from England a great deal, and, in the second place, we have had several serious accidents. The high-class steel wires—plow rope—which are used for stays are not always reliable. On two occasions these wires have broken, and, becoming entangled in the wheels, have made a complete wreck of the wheels and everything about them. The last breakdown will take about a month to repair, and I shall put in a lower class of steel in all the stays that are near the wheels.

This damage was duly repaired, and the experiments were resumed early in 1893. In one of these, with a spread of somewhat more than half of the sustaining surface which the apparatus is designed to carry in full flight, M. *Maxim* succeeded in obtaining, at a speed of 25 miles per hour and with a thrust of the screws of 1,000 lbs., a lift over the front wheels of 2,300 lbs., and over the hind wheels of 1,900 lbs., as recorded by the dynagraphs. On a subsequent run, after making some alterations, he succeeded in obtaining, at a speed of 27 miles per hour and with a thrust of screws of only 700 lbs., a lift over the front wheels of 2,500 lbs., or quite all the weight resting on them, and of 2,800 lbs. over the hind wheels; thus showing a total lift of 7.57 lbs. per pound of thrust, as against 4.20 lbs. lifted per pound of thrust on the former occasion.

M. *Maxim* published the diagrams illustrating both these runs (and still another subsequently made) in the London *Engineer* for March 17, 1893, and gave a description in which he stated that the principal lift was obtained from the large aeroplane of 2,894 sq. ft. in area.

The run last above described was made on February 16, 1893, and on the same day two more runs were made until stopped by an accident.

First, an additional pair of wheels was attached under the front end of the machine, connected in such a manner that the small and lighter wheels could lift 3 in. from the track. Three men were also placed over the forward axletree, and a run was then made with 900 lbs. pull on the dynamometer. After the machine had run about 400 ft. the light wheels lifted clear of the track, and when the engines were stopped they came back to the track all right. The machine was then run again with 1,000 lbs. pull on the dynamometer, with the following result, described in a letter to the writer from M. *Maxim*, dated February 21, 1893.

I have had another accident with my apparatus.

My main aeroplane is 50 ft. wide and 47 ft. long in the direction in which the machine travels. I had another aeroplane directly in front of the engine, which was about 18 ft. long and 4 ft. wide. On the first runs which I had been making I found a great deal of atmospheric resistance which I could not account for except that it resulted from the bagging of the main aeroplane and the resistance offered by the numerous struts and wires which I used in my attempts to keep it approximately flat. With the engines running at a sufficient speed to give a push of 1,325 lbs., it was found that the lift on the aeroplane did not much exceed the push of the screws.

I then made a radical change in the manner of holding the plane flat, and tried my first experiments after this with a push of 800 lbs., when it was found that the lift was a great deal more than it was with the 1,325 lbs. in the previous experiments; in fact, the lift on the front pair of wheels was equal to the weight resting on these wheels, and the machine was only kept from leaving the track by the weight of three men whom I carried directly over the front axletree. This I regarded as dangerous. I then attached two very large cast-iron wheels in such a manner that the light wheels could lift some inches from the track before the heavy wheels were lifted at all, the weight of the heavy wheels and their axletree being about 1,400 lbs. Three men were also added to this load.

In making the run the gas was carefully turned on until the engines gave a push of 1,000 lbs. I had noticed that as the machine advanced and the engine ran faster, the boiler pressure was diminished. I therefore, upon starting, turned on a little more gas, so that the pressure, instead of falling, increased slightly during the run. When about 400 ft. had been covered, the two front wheels lifted off the track, leaving the heavy wheels still on the track; but just before stopping the heavy iron wheels also lifted from the track, and when the engines were stopped one of the wheels got into the soft earth, sinking down and tilting the machine over to one side. A gust of wind then tipped the machine on its side; but the breaking, which was confined almost entirely to the framework for holding the cloth, was caused by the impetuosity of a lot of men who tugged away at my ropes, and putting a strain downward instead of upward on the ropes, succeeded in completely destroying the framework.

The speed was 27 miles an hour, and the pressure of steam about 200 lbs. The lift recorded was nearly 6,000 lbs., as shown by the diagrams taken from the dynographs. The incline of the main aeroplane was, however, very steep, being about 1 in 9.

The lift was more than I expected. I did not think that a plane so very large, especially in the direction in which it was traveling, would be so efficient. I thought I should have to depend more on the narrow planes which extend beyond the main plane. This more than expected lift, however, may have been due to the wind, during the last end of the run, being contrary to the direction in which the machine was traveling.

I think that these experiments demonstrate that an aeroplane may be made to carry a considerable load.

It will take some time to repair the damage. None of the expensive machinery was damaged in the least. I shall take greater care in the future not to experiment when there is a liability to squalls, and shall have a fender, so that if the machine gets off the track it will not topple over.

It is understood that at the time this run was made about half of all the sails were in position—namely, 3,160 sq. ft. The power which the engines developed was about half of their full power, so that it will be realized that there will be ample lifting power when free flight is attempted.

Since then the apparatus has been repaired, and in an article which has been extensively published in American newspapers, a correspondent, writing under date of London, September 12, 1893, gives an account of a ride which he took on the machine. After describing it and the house in which it is sheltered, he says:

I mounted the platform, made of light matched boards so thin that they seemed scarcely able to bear a man's weight. Prior to the start a rope running to a dynamometer and post was attached behind, to measure the forward impulse or push of the screws. . . . The action of the screws caused very little shaking through the whole machine, and this was a surprise to me, comparing the tremendous force with the delicate framework. Behind the ship, 10 ft. away, two men were shouting from the dynamometer and indicating the degree of push on a large board for the engineer to read. The index quickly marked in succession 400, 500, 600, 700, and finally 1,200 lbs. of push, and then the commander yelled, "Let go!" A rope was pulled, and then the machine shot forward like a railway locomotive, and with the big wheels whirling, the steam hissing, and the waste pipes puffing and gurgling, flew over the 1,800 ft. of track. It was stopped by a couple of ropes stretched across the track working on capstans fitted with reverse fans. The stoppage was quite gentle. The ship was then pushed back over the track by the men, it not being built, any more than a bird, to fly backward.

M. *Maxim* is quoted by the correspondent as saying, among other things, concerning his apparatus:

Propulsion and lifting are solved problems; the rest is a mere matter of time. . . . Haste in such a venture is the worst of policies. Weak points must be thoroughly sought for, and everything made completely safe before the public is invited to consider the air ship as a practical means of transit. I am looking for a location with more room for me to experiment in than I can find in England. I am cramped here for want of space.

Such is the present status (1893) of this bold and costly attempt to solve the problem of aviation with an aeroplane. M. *Maxim*, as he says himself, may not achieve final success; but he has, in the opinion of the writer, very greatly advanced the chances of eventual success. He has constructed, it may be said invented, a steam engine with its adjuncts developing 300 horse power, and weighing only 8 lbs. to the horse power—an achievement hitherto unparalleled, and probably the most important problem to solve before man can hope to succeed in navigating the air at will.

There doubtless remain other problems to be worked out practically, notably that of effectually controlling a flying machine while in the air, both in the vertical and the horizontal direction; that of maintaining the equipoise under all circumstances of speed and angles of incidence, and also those of devising methods of starting up and of alighting safely anywhere; for in practical operation, even for war purposes, M. *Maxim's* machine cannot always be brought back to get a start upon its initial railway track.

There probably also remain some questions to be settled as to the best forms, extent and texture of the supporting surfaces; and it is not impossible that his experiments will eventually lead M. *Maxim* to a complete remodeling of his aeroplanes; but, as has been pointed out in discussing "screws to lift and propel," it is already within his power, by reason of his marvelously light steam-engine, to go up into the air with an aerial screw, and to perform therein various evolutions.

In any event, the name of M. *Maxim* must ever remain as that of one of the men who have hitherto done most to advance the solution of the problem of aviation.

(TO BE CONTINUED.)

CARE OF MARINE BOILERS.

By Robert Forsyth.

The boilers are the most expensive and perishable parts of the machinery of a steamship, often requiring to be replaced two or three times in the life of a vessel.

Deterioration and decay begin as soon as the boilers are in use, and are only partially prevented by care on the part of designers and engineers. At the present time the demand for large and fast steamships necessitates the use of boilers of great size and cost. The attention of builders and owners is, therefore, directed to keeping this portion of the machinery up to the highest point of utility for the longest period at the least expense.

Ten or 15 years ago eight years' work was considered a good average for a marine boiler, but the period of usefulness has been increased fully 50 per cent. within a few years. This gain is due in a measure to improved design and construction, but more, probably, to the more intelligent care bestowed upon boilers by modern engineers.

The first and simplest thing to guard against is

EXTERNAL CORROSION.

This arises from various causes—drips from leaky decks, leaky screw-stay bolts, leaky hand-hole plates, joints, stuffing-boxes, etc.—and from a cause so apparent that it would not be noted if it did not occur so often—namely, the neglect to water-proof portions of the boilers directly under hatch openings.

There is no good reason for the existence of any of these causes of corosion, yet they do exist and create a constant demand for the boiler maker's panacea—a "soft patch." The most serious point of external corrosion is the front of the ash-pan and the adjacent portion of the boiler head. The use of firing tools, wetting down of ashes and other causes, conspire to render corrosion at this point very rapid.

It may be counteracted in part by the persistent use on the ash-pan fronts of the waste oil or grease from the engine-room. A better method of protecting this part of the boiler, though seldom applied, is to fit soft patches or wearing plates of $\frac{5}{16}$ in. iron over the seams connecting furnace to front head, and extending over the lower part of the front head, to take in the front seam of the shell. This should be done when the boiler is new, and, although these wearing plates will last only a few years in active service, their renewal is simple and inexpensive, and therefore to be strongly recommended.

Four years' wear in hard service has been had from the wearing patches by keeping them smeared with the waste oils from the engine-room.

Wash of bilge water upon the shell is another cause of corrosion, and when the vessel is so designed that it is impossible to prevent the shell being wet by bilge water, it becomes necessary to keep the shells covered with some anti-corrosive material. The writer of this article has had a long practical experience with corroded boiler shells and the many preventives therefor, but has found nothing better or cheaper than coating the boiler shell below the furnace line with a mixture of engine-oil drippings and plumbago while the boiler is warm.

With ordinary intelligence bestowed upon the care of marine boilers, there is no reason why their period of usefulness should be shortened by external decay.

INTERNAL DECAY

is a much more serious matter. The chief causes of trouble inside boilers are: use of sea water, dirty fresh water, greasy water, cold feed water, imperfect circulation and contracted water spaces.

Using steam at a pressure of 160 lbs. per square inch evolves difficulties that did not exist at 75 lbs. per square inch. At the latter pressure a little supplementary feed from the salt water side of the condensers would give a coating of lime inside the boiler, prevent pitting, and the oil coming with the feed water would rapidly rise in the slightly brined water to the surface, and could be cared for by the scum valve; but while a $\frac{1}{16}$ in. scale on a back tube plate would not cause trouble at a working pressure of 75 lbs. per square inch, at 160 lbs. per square inch another condition of affairs exists. The tube plates having been thickened for increased temperature, the tube ends will leak from a very slight deposit on the tube plate.

The spray from a leaky tube end wetting the particles of ash, coal and dust carried by the draft forms a deposit on the other tube ends, and the furnace is rendered useless. If two furnaces are common to one chamber, both are disabled, much disagreeable labor is entailed, expanding the leaky tube, and this must be done repeatedly until there is an opportunity to thoroughly clean the boilers.

There is also danger, under forced combustion, of the tube ends leaking enough to cause a back draft from the furnace into the fire-room.

In the days of low-pressure boilers a thin scale was considered rather an advantage and protection to the inside of boilers, and it is difficult for engineers accustomed to that type of boilers to realize the changed condition with higher pressure.

Corrugated furnace crowns are seriously injured by even a thin scale, and it will be found that the corrugations near the middle of the grate, perhaps a little nearer the furnace front, suffer most. At this point the repeated opening of the furnace doors, and consequent change of temperature, causes the scale to crack, a new coating is formed, is again cracked, and so on repeatedly until, in some cases which have come under my observation, the scale after a 20 days' run had formed in leaves, attached to the corrugations like the leaves of a book to the binding, with the open edges of the leaves, about 1 in. over all, toward the front of the furnace, and the attached edges, about one-eighth of an inch thick, toward the back.

This shows that the evaporation is much greater at this part of the boiler; also that the corrugated furnace, if of good material, actually performs the duty for which it was designed—viz., expands and contracts without tearing the connecting seams of the tube sheets.

In the effort to prevent the formation of this scale it is customary to stop the supplementary salt-water feed and use instead distilled water from the evaporators. This frequently leads to serious trouble from the presence of grease in the feed water. Deposits of grease on the hotter parts, such as furnaces, lead to overheating and collapsing of furnace tubes; also to leakage at laps of back connections.

In parts of the boiler where less active generation of steam takes place pitting is sure to follow. The under sides of boiler tubes suffer most, also the sides of furnaces about the line of the grate bars; the rounded part of flange of back tube sheet, and sides and bottom of combustion chamber, below the approximate line of upper grate bars and near the water-line on shell and heads.

The pitting in these places is rapid and frequently unobserved in the earlier stages, the pitted parts being covered with a black moderately hard oxide, which, being removed by thorough washing and scraping, discloses the true condition of the metal attacked.

To prevent this overheating and pitting, from the presence of oil or grease, many remedies have been used with varying results. Filters of various kinds are among the most successful devices, sometimes applied on the suction side and some-

times on the delivery side of feed pumps. These filters are of various materials—sponges, blankets, coke, charcoal, gunny-sacks, horsehair, tan bark, hay, etc.—each being strenuously advocated by its particular selling agent, but the results depend more upon the care and judgment exercised by the engineer than upon the material of which the filter is made.

The filter which presents the greater surface in a given space, which can be readily replaced, and the material for which can be obtained at any port at small cost, will commend itself to engineers. But a filtering tank, filled with ideal material, will mechanically trap only a small percentage of grease if the filtering material is not frequently cleaned and renewed.

The designer of a filtering tank should bear in mind that the location, accessibility, and facility with which covers and interiors can be removed and replaced is of vital importance. Wass's air and grease extractor has been used with more or less success, depending upon the care and judgment of those using it. This filter is an enlarged chamber, on the discharge side of feed-pipe, with cross bars inside giving passage for the water, alternately over and under; a float operates an air and grease escape valve; by-pass valves and mud blow-off valves are also provided. Its operation is based upon the fact that the lessened velocity of the water in the enlarged chamber gives time for the grease to come to the surface and be automatically blown off by the accumulation of air operating the float valve. The mud, if any, will settle to the bottom and be blown off.

On one of the Puget Sound steamers, having a compound engine fitted with slide-valves, and using a working pressure of 120 lbs. per square inch, this filter was used, but the engineer, considering the amount of oil used on the valves excessive, stuffed the spaces between the division plates with hay, thereby greatly increasing the utility of the grease trap. The hay was renewed every day. Hay stuffed in gunny-sacks and blankets has been used with advantage in ordinary feed tanks, care being taken that all the feed water passes through the filtering material.

Efforts have been made to catch the grease in the main engine exhaust pipes, hoping thereby to keep the condenser as well as the boilers clean, but reports are conflicting as to the success of this device.

Feed heating arrangements assist materially in getting rid of grease. Gilmour's feed heater is a large chamber, fitted between feed-pump and boiler, necessarily a few feet above the working level of the boiler, into which is discharged, about half-way up, the feed water, filling the heating chamber about two-thirds full. A little below the feed inlet is an internal perforated steam-pipe with suitable regulating valve. The steam by direct contact heats the water almost to pressure point, and the sludge is precipitated to the bottom of the chamber.

A triple-expansion engine of about 1,500 I.H.P., fitted with this heater, has been under my observation for three years, and, with no other grease extractor, the boilers have been kept absolutely clean while on quite a hard service.

Cold feed water is injurious to boiler shells, furnaces, and furnace seams, and feed water should be heated to within a few degrees of the steam temperature before being discharged into the boiler, but this practice is not in general use. Weir's feed heater is one of the best in use, but is cumbersome, has many valves and pipes, requires two pumps, and the temperature is limited, being on the suction side of pump.

Direct injection of steam into the ordinary feed tank, and heating by coils in tank are open to the same objections. Discharging into the boiler with a series of inside pipes renders boiler cleaning more difficult. Heating the feed water by direct contact with steam, as by Gilmore's heater before mentioned, is so simple and satisfactory that it seems to meet all requirements.

When feeding with water from rivers or city supply, the direct contact of steam for heating, in a large chamber, where the velocity would be low, would precipitate most of the earthy matter.

Efforts have been made to neutralize the effects of oil in boilers by injecting sal soda, caustic soda, lime water, and potash with the feed water; but as the best cylinder oils are pure mineral oils and do not saponify, the results have not been satisfactory.

Zinc slabs in parts of the boiler showing decay seem to retard it somewhat, though a large quantity, sometimes amounting to tons, has been used without satisfactory results.

It will be found that boilers fed by an independent feed pump with feed water (from a surface condenser, *not leaking*), aided by an evaporator, filter, and heater, have very little tendency to pit below the line of the grate bars when an efficient system of mechanical circulation is maintained.

The use of the hydrokineter warms the water in lower parts of boilers when getting steam, but constant circulation is necessary, especially under banked fires, and the water should be pumped continually from lower front end of boiler to upper back end.

The value of this simple method is generally underestimated, and on many vessels the pumps are not fitted up for the purpose. Constant circulation by pumping prevents the lower shell seams being strained by unequal expansion, and reduces pitting below the grate line to a minimum. The benefit derived from constant circulation below the grate level seems apparent when we consider how little pitting takes place between the grate line and top of combustion chamber. In two-furnace boilers pitting below the grate line is greatly in excess of that in three-furnace boilers, a difference due to the better circulation maintained in the latter by the location of the middle furnace.

The tubes used in most vessels at present are greatly superior in make and quality to those in use 15 or 20 years ago, and when of No. 8 or No. 9 gauge will last six or eight years, giving little trouble. If only of standard thickness, however, which does not allow sufficient margin for scale spots and other surface imperfections, constant leakage will occur, whereas in the thicker tubes the result would be only an increased roughness of the surface.

If tubes are placed too close together cleaning is difficult, and tubes are liable to be burned at the back ends from an insufficient supply of water to tube plates. Tubes spaced to give 50 per cent. water surface to tube plates give practically no trouble, but if spaced to give only 40 per cent. are likely to make the water in boilers foam, and give endless trouble to keep back ends of tubes tight in the tube sheets.

When the tubes are overcrowded in the boiler various methods are resorted to, such as ferrules and cements, to prevent leaking of tube ends. But all such devices are merely temporizing with the difficulty, which exists primarily in the defective design.

The use of steam at 160 lbs. per square inch has led to the abolition of that danger trap, the superheater, one of the most formidable foes of the old-time boiler-room, fitted as they were with one, two, three, or four vertical flues hooped with angle irons, and usually too narrowly spaced to permit inspection. Corrosion and pitting could go on *ad libitum*, and usually the first intimation of trouble would be the bulging of the flues. The interior could not be examined without cutting the shell.

Now that boilers are made a little larger, giving more water surface for steam to escape, the necessity for a superheater no longer exists, nor do the difficulties which it was intended to obviate.

On the flame side of the furnace decay takes place at the point of contact with the bridge wall, and as the deterioration covers a large surface, it is apt to escape detection until the plate is quite thin. By placing thin sheet iron between the bricks and the furnace plate each time the bridge wall is rebuilt the decay may be retarded. Around the manhole joint, in the interior surface of the plate, pitting occurs partly from the presence of suphur in the rubber gaskets, and partly from repeated buckling opening the surface of the plates.

The wear of boilers depends much upon the character of the service in which the vessel is employed. Tug boats, bay steamers and coasters, in the order mentioned, seem to suffer more than ocean steamers.

Irregular application of heat, lying under banked fires for long periods, and irregularity of washing out boilers, will account in a great degree for this difference.

The care of a marine boiler when not steaming is of great importance. If empty, it should be quite dry; if it contain water, it should be *quite full* and have no leaks. Sudden stopping of engines, without an independent air-pump to care for the steam, is a constant source of injury to boilers, as it is difficult to check the pressure without notice. There is, of course, no difficulty with independent air-pumps to care for the steam.

The use of forced draft has added to the difficulty of caring for boilers, especially with the closed fire-room system as the admission of cold air when the furnace doors are opened is the worst possible treatment for back connections and tubes. The induced draft system is little, if any better, either with the fan or the jet in the smoke-stack. The alternate high and low temperature from the intense heat of the fires, and the inrush of cold air when the fires are replenished, demands a very elastic duty from materials and conditions that are the reverse.

Forced draft with the closed ash-pit system affords better control of the steam-making power, and depends less upon the trim of ventilators or direction of the wind, especially in the tropics, where fire-room duty is always severe. It is also free

from the great objection of admitting a rush of cold air when fires are replenished The main objection to its use is the increased length of fire-room required with the ordinary type of marine boiler, but its use in moderation is extending, and all the appliances to supply it are of the most permanent and durable character.

This system does away with the difficulties arising from handling coal from different bunkers and discharging ashes, which are encountered with a closed fire-room, and the longest voyages may be made with a regularity of steaming impossible with a closed fire-room or natural draft.

The foregoing remarks apply particularly to the ordinary type of marine boiler, but of late years the demand for high pressure and less weight per horse power has brought into use various forms of water-tube boilers, the care of which is equally important. All that has been said as to the necessity of supplying pure water is more imperative with the water-tube boiler than with the older type. Being more flexible, the water-tube boiler suffers less from forced draft with closed fire-room, but, being more susceptible to change of temperature and having a small storage of water, will suffer greater loss, from a steam-making standpoint, than if used with closed ash-pit system. The rapidity with which steam can be raised from cold water, and the reduced weight per horse power, ensures a favorable consideration for this type of boiler; but the actual durability is yet to be demonstrated.

The life of grates, bridge walls, and furnace fronts depends almost entirely upon the coal used. With Pacific coast, Australian, Japanese, Chilean, and the lower grades of English and Scotch coals, the furnace fittings wear well, the linings of the fronts and doors suffering most when the fire is too near the front. With good grades of Welsh or Pennsylvania coal the wear is much greater, especially if dampers are used suddenly to prevent blowing off steam when it is necessary to stop the engine quickly.

The most durable grate bars are the thinnest, and wrought iron is preferable, as these can easily be straightened or pieced out aboard ship, when cast-iron ones might not be obtainable.

Breechings, front connections and doors require constant attention when lignite or flaming coal is used, and if not kept in repair add to the consumption of coal and interfere with the draft. With patching and repairing, front connections, doors, and uptakes will usually last as long as the boilers; not so with the smoke-stack. In active service, ten years is a long life, but this, again, depends on the quality of coal used. If flaming coal is used the smoke-stack has a very short life, not more than three years with some of the lignites.

The outside of the smoke-stack is protected by paint, but as yet we know of nothing that would afford protection to the interior. A few vessels are provided with hoods to protect the smoke stack when laid up, but these are seldom used when the vessel is in commission.

It is the custom of late years to cover the greater part of boiler shells with non-conducting material, and to cover this again with some water-proof material, either sheet lead, galvanized sheet iron, or painted canvas. If either of these water-proof coverings are permitted to leak, the non-conducting material, being porous, absorbs the moisture and causes corrosion. There are numerous non-conducting coverings which, when properly put on and kept water-tight (which is seldom), will last as long as the boiler.

Bottom and surface blow-off valves, feed-check valves, and gauge cocks require constant attention. The scour from blow-off is particularly bad on the seats of the blow-off valves, and, if neglected and permitted to leak, entails serious trouble with blow-off pipes. These valves should be ground in or faced up frequently. In using the blow-off at sea the gradual and simultaneous closing of outboard and inboard valves will greatly reduce wear on pipes. In these pipes the dynamic effect of the sudden change from cold water to hot pressure, and reverse, is very great and will sometimes split the heaviest pipes.

The gauge cocks must of necessity be blown through to keep them free, and if the composition contains zinc they last but a short time. I have renewed them after three months' wear, when the keys looked more like sponge than metal.

Boilers well designed, constructed of the best materials, and equipped with the most approved fittings, may be a source of constant annoyance and expense for lack of intelligent care in the matter of raising steam and blowing off the water. If boilers and pipes are slowly and equably warmed before pressure is raised, a most fruitful source of leakage is avoided.

When, at the end of a voyage, steam pressure is blown off, dampers and doors should be closed and the water left in the boilers to cool gradually (a couple of days if practicable) before being pumped out. Attention to these details will be well repaid by the absence of leaks, which are inevitable when boilers are blown out with steam pressure.

The length of time a boiler of the present type may be used varies so much under different conditions that it is difficult to arrive at a satisfactory average.

I may instance two sets of boilers, of the same type and on similar service, one set of which was renewed after eleven years' service.

These boilers were steam-tight at a working pressure of 60 lbs., and from the furnace side were apparently as good as ever. Yet the back connection sheets were found to have been reduced in thickness by decay from $\frac{7}{16}$ in. to barely $\frac{3}{16}$ in. in thickness. Where decayed the combustion chamber had only 1½ in. to 2 in. space between that and the shell.

The other set of boilers, having 3½ in. to 4½ in. water space around combustion chamber, was found to have worn very little at these points, and was continued in service three years longer.

Another marked instance has come under my observation, where the machinery of two vessels on same service show marked difference in wear. The boilers in one vessel required renewal after seven years' service, while in the other they have now been running 16 years, and appear to be good for many years more. In the latter case the same chief engineer has had charge of the machinery from the beginning of service.

In one instance, of boilers 18 years old, I had the back tube plate (after the boilers were cut apart) knocked around with sledge hammers until it was doubled over upon itself, without showing any sign of cracking; and I think something similar will be found with the majority of old boiler plates *if the material has been good* when the boilers were new.

As boilers have been built and equipped, their life has been about 12 years, with pressure from 60 lbs. to 90 lbs. per square inch, and while they could be repaired and run longer at lower pressures, it would not be a commercial success to do so.

Among the many old boilers I have repaired or removed, I have found that, as a rule, comparatively little decay has taken place above the bridge walls, and the shells were pretty good except the lower parts, but the furnace, ash-pan, lower back connection, and lower stays made me wonder how it was possible for the parts to hang together and stand a pressure test.

With the superior quality of steel available for the construction of boilers at the present time, drilled holes, improved workmanship, and the use of corrugated or other elastic furnaces, the life of boilers may be much longer than formerly. Sufficient water spaces around the connections, evenly distributed bracing, tube space not crowded, the use of hot, filtered feed water, and mechanical circulation of water in boilers, will, I think, with the renewal of tubes and furnaces, prolong the life of marine boilers to nearly 20 years, under the supervision of intelligent engineers, notwithstanding the fact that the pressure has been advanced to 170 lbs. per square inch.

"Eternal vigilance is the price of safety" in the case of steam boilers, and the engineer who despises small things will be continually beset with small troubles, which, in the aggregate, will greatly reduce the period of service of boilers and engines.—*Journal of American Society of Naval Engineers.*

"SCHNEBELITE"—A NEW EXPLOSIVE.

Experiments were made recently in England with yet another "smokeless explosive," the invention of a Frenchman, M. l'Abbé Schnebelin, and called, after him, "Schnebelite gunpowder." The basis of this powder is chlorate of potash, a substance which has hitherto been used only for the manufacture of detonating compounds, on account of the facility with which it can be detonated by percussion or friction when mixed with some inflammable material such as sulphur or black sulphide of antimony. In fact, the mixture of chlorate of potash and sulphur was used in the earlier patterns of percussion caps for muskets, and the mixture with black oxide of antimony is still employed in the ordinary friction tubes with which the charge in muzzle-loading guns is usually fired. The violent detonating property of these mixtures is due to the fact that the chlorate parts with its oxygen at a much lower temperature than the nitrate of potash—the oxidizing agent in ordinary gunpowder—and also to the peculiarity that, when decomposed by heat into oxygen and potassium chloride, it is attended with evolution of heat, while in most cases of chemical decomposition heat is absorbed.

In "Schnebelite" the chlorate of potash is mixed with pure cellulose, or woody fiber, such as is used for the manufacture of guncotton or Schulze powder. The advantages claimed for it by the inventor are numerous, the principal being as follows:

1. Facility and cheapness of manufacture.
2. Almost smokeless.
3. Very slight recoil.
4. No fouling or oxidation of the rifle.
5. Unless confined will only burn gradually, and not explode.
6. Imperishable, retaining its properties even after being wet, and involving no danger when heated.
7. Non-explosive by concussion or friction, and requiring 540° F. to ignite it.

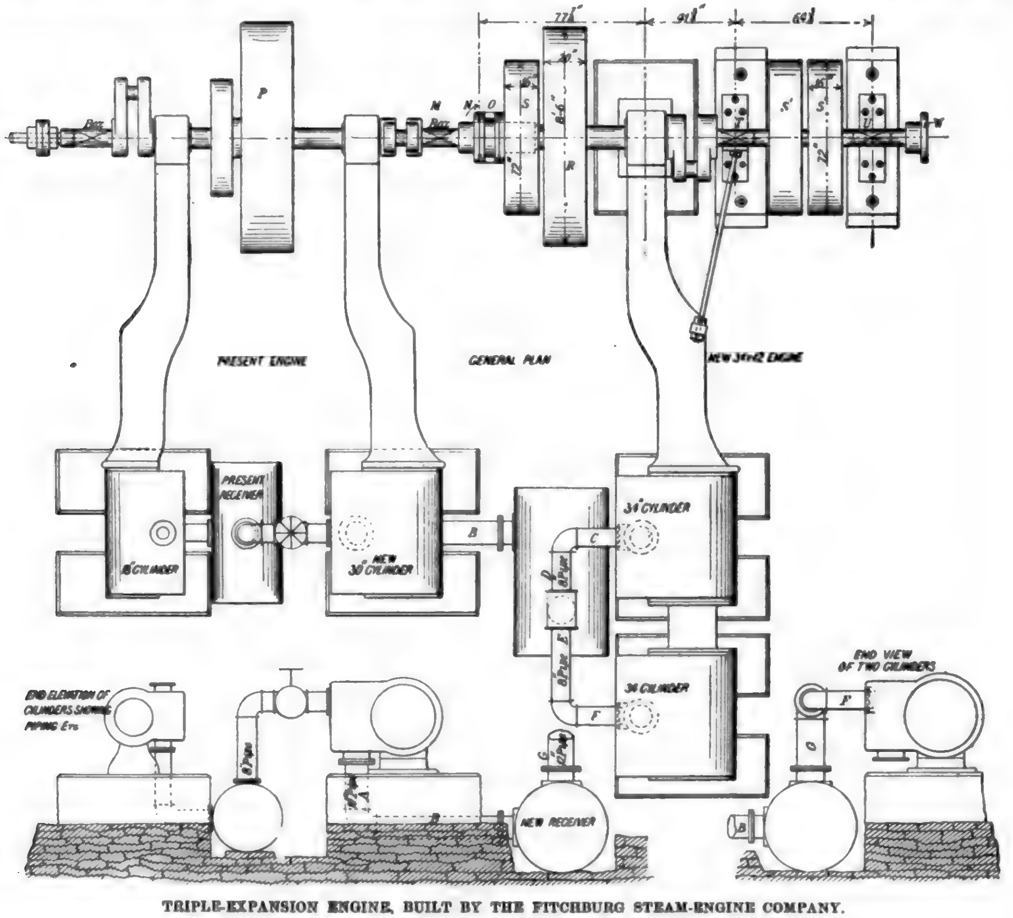
The appliances at the disposal of the Abbé, who conducted the experiments personally, were not sufficient to allow of any exhaustive tests of this explosive as to its value as a propelling agent as compared with the powders now in use. But these trials were so far interesting that they proved conclusively that the inventor had succeeded in producing a gunpowder with chlorate of potash as its base, which, notwithstanding the generally accepted opinion of the violence of compounds in which this substance is used, appears to be completely under control. When fired from the new magazine rifle the recoil was very small, while the penetration of the bullet through both wood and steel plates was such as to show that the velocity obtained was satisfactory, though there was unfortunately no means of measuring it. The charge employed was about 20 per cent. greater than that of service powder, and it claimed that the pressure on the barrel of the rifle is very small. The smoke was light and very quickly disappeared, while the fouling of the bore was very slight. The claim to non-heating of the barrel was not, however, proved, as after the firing of 10 rounds with rapidity the barrel in front of the chamber was decidedly heated, though it could be handled without discomfort.

The trial in a sporting gun showed that this powder is about equal in hard-hitting to the ordinary E. C. powder.

To exhibit the safety of this new explosive a quantity coarsely granulated was ground into fine powder in an ordinary coffee-mill; another sample was struck by a heavy hammer on an iron anvil, and when thus reduced to powder was ignited by a match and burnt quietly away.

A charge of small shot was fired into a box containing about a quarter of a pound without producing any ignition or explosion, and the same was done to four small cylinders (for use in blasting), the broken fragments and scattered powder being in each case collected and burned in the open without any explosion.

Though only preliminary and inconclusive, these experiments indicate that this explosive has several qualities which would render it suitable for use as a propelling and a destructive agent, but much more exhaustive and detailed experiments are necessary before any decided opinion can be arrived at. The safety and facility of manufacture, and its cheapness, are in its favor; some of this powder was made in the morning after the visitors arrived on the ground, taking only a few minutes, and this same powder, after being dried for a couple of hours, was fired from the shot gun in the afternoon, with excellent results as to penetration.—*London Times.*



TRIPLE-EXPANSION ENGINE, BUILT BY THE FITCHBURG STEAM-ENGINE COMPANY.

NOVEL TRIPLE-EXPANSION ENGINE.

Some time ago the Fitchburg Steam-Engine Company, of Fitchburg, Mass., built a compound condensing engine with cylinders 18 and 34 in. in diameter by 42 in. stroke, for Spring

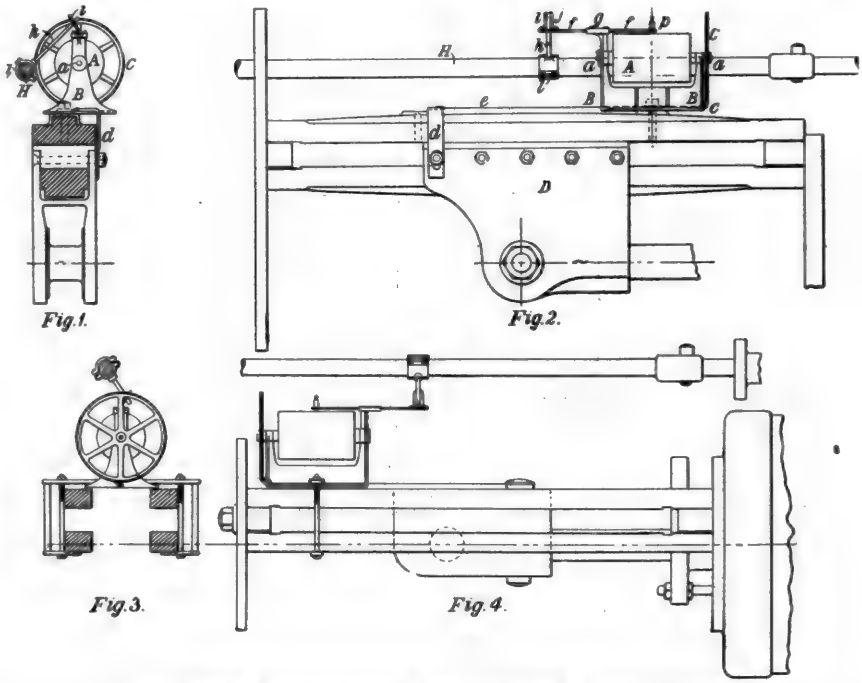
Forge, Pa. The engine was coupled directly to the main shaft, the engine shaft ending at the coupler marked *N* in our illustration, from which point the main line shaft extended 200 ft. or 300 ft. The shaft also extended in the opposite direction a short distance, a portion of the power being taken at that end, but the main part through the coupling *N*. The fly-wheel *P* is very small, because it is necessary to permit passage by it, but it is also very heavy, as its rim is nearly a foot thick.

The 500 H P. developed by these engines proving insufficient, the plan was suggested by the Fitchburg Steam-Engine Company of removing the line shaft from the half coupler *N* to the coupler *W*, and inserting an entirely new engine with the necessary shaft, leaving the driving pulleys as shown at *S S S*, and putting in a shaft of the proper size for the engine toward the coupler *N* of 8 in. in diameter from the engine to the coupling *W*, with two very heavy boxes at *T* and *U*. The fly-wheel *R* is also very heavy in the rim, because it was necessarily made small. The driving pulley *S* is fitted in halves to

VALVE-MOTION INDICATOR USED ON THE BALTIMORE & OHIO RAILROAD.

The movement and action of the slide-valves of a locomotive is probably more difficult to understand clearly, and is of more importance to the satisfactory working of the machine, than any other of its purely mechanical functions. Any device, therefore, which will represent this action with absolute correctness and clearness, and will show exactly the *actual* movement of the valves of locomotives, must be a great help in the diagnosis of their defects and disorders. A device which does this with absolute precision is illustrated by our engravings, for the drawings of which we are indebted to its designer, Mr. F. J. Cole, Mechanical Engineer of the Baltimore & Ohio Railroad, who says in a letter to the editor of this paper:

"The primary idea of this indicator was taken from your 'Catechism of the Locomotive,' but this instrument was designed with a view to its rapid application to an engine, by



VALVE-MOTION INDICATOR USED ON THE BALTIMORE & OHIO RAILROAD.

the hub of the coupling to save room, and there is inserted a coupling, *O*, in halves diametrically, so that this can be taken out and the shaft moved endways to get at the boxes or to remove the crank-pins when desired. The reason for crowding the engines into this small space is that there was no more room available, and the company's works were so located that no enlargement was possible.

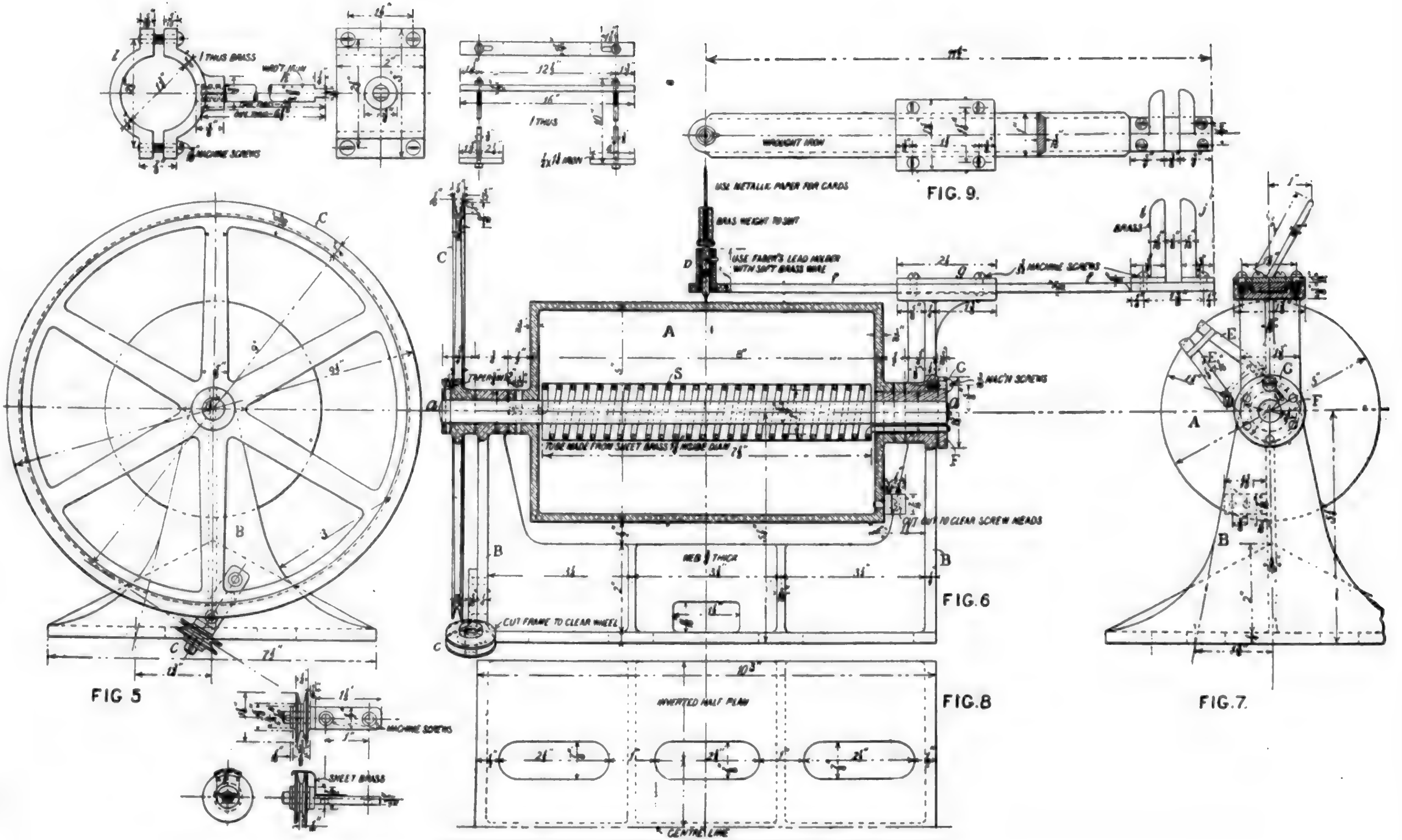
The old 34-in. cylinder of the original compound engine was removed from the low-pressure side and one of 30 in. in diameter substituted for it. Two 34 in. tandem cylinders were placed upon the new engine and the exhaust from the 30-in. cylinder taken into a steam-jacketed receiver, and from this by distinct pipes to the two 34-in. cylinders, the exhaust being taken from them to a Bulkley condenser of sufficient size for both cylinders. By the addition of these two cylinders and with a steam pressure of 125 lbs., the engine readily develops 700 H.P., and while the conditions are peculiar so far as connecting directly into a line shaft are concerned, everything seems to work with entire satisfaction, and there is no trouble with belts or gears.

The engine makes 90 revolutions per minute, giving a piston speed of 630 ft. The general arrangements are very clearly shown upon the engraving. A heavy bolt was led off from the engine bed to the bed-box, as shown, so as to strengthen the resistance of that box against the strains of the steam.

merely clamping it to the guides and attaching the string to the cross-head key."

Figs. 1 and 2 show the instrument applied to a Laird cross-head and guides, fig. 1 being a transverse section through the guides, and fig. 2 a side view. Figs. 3 and 4 are similar views, showing its application to an engine having the ordinary type of four bar guides. Figs. 5, 6, 7, 8 and 9 are detail views, engraved to a scale of one third of full size, and fig. 10 shows a series of diagrams taken from an engine with a maximum travel of valve of 4¾ in., and fig. 11 shows a similar series of diagrams taken from the same class of engine, with the eccentrics changed so as to give a maximum travel of 5¼ in.

From fig. 2 it will be seen that *A* is a cylindrical drum, which is carried on a horizontal shaft *a a*, which is clearly shown in the horizontal section, fig. 6. The shaft is supported by a cast iron stand *B B*, which is bolted to the top guide, in this case by means of bolts screwed into the holes which receive the oil cups. The right-hand end, fig. 2, of the shaft has a large pulley *C* attached to it. To the back end of the cross-head an angle or ⅂ shaped bar *d* is bolted, to the upper end of which one end of a twine *e* is attached. This extends to and passes over a small pulley *c*—shown clearly in figs. 5 and 6—and then around the large pulley *C*, and to which the other end of the twine is fastened. It is obvious that if the cross-head in fig. 2 is at the right-hand end of the guides, its



VALVE MOTION INDICATOR, USED ON THE BALTIMORE & OHIO RAILROAD.

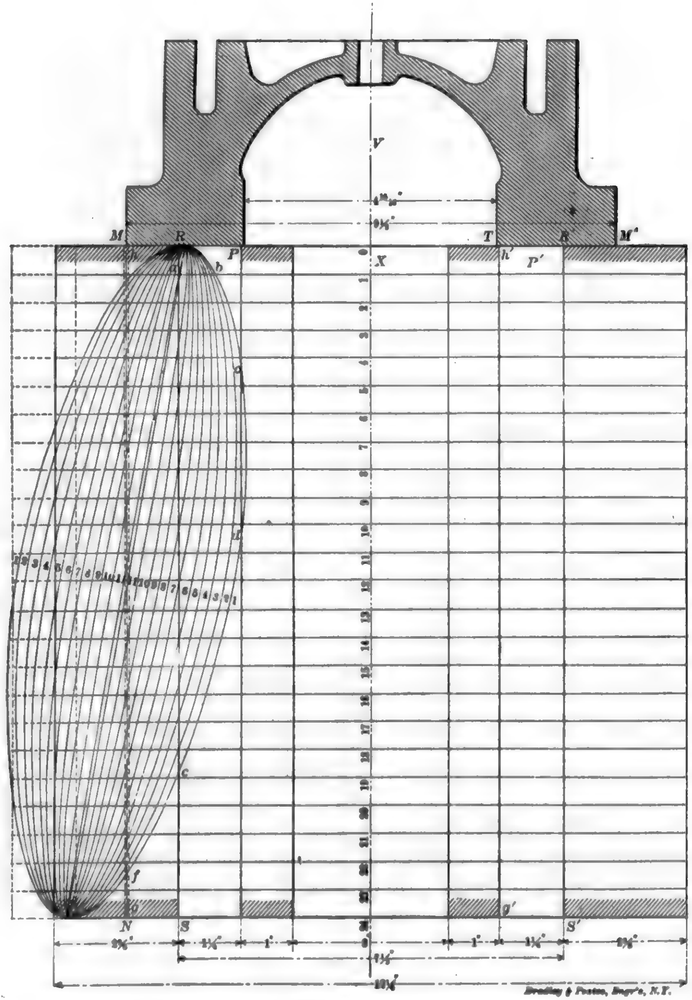


Fig. 10.

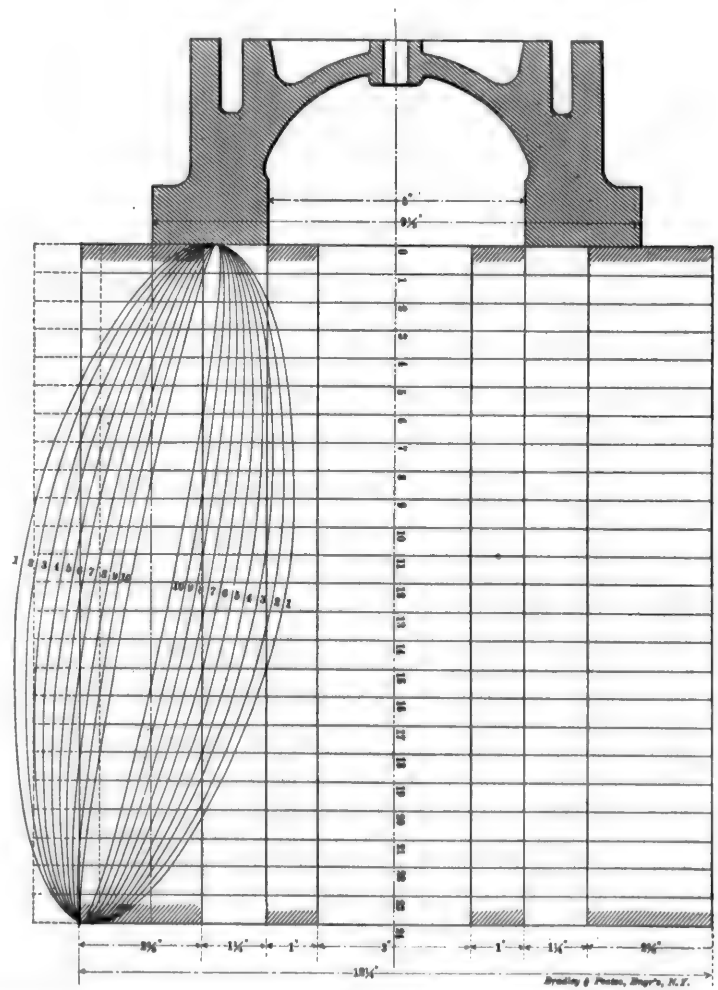


Fig. 11.

SLIDE-VALVE DIAGRAMS TAKEN ON THE BALTIMORE & OHIO RAILROAD.—SCALE ⅛.

movement toward the left will thus cause the drum A to revolve. A helical spring S, fig. 6, is wound around the shaft $a\ a$ and attached to it at one end, and to a sleeve F, which is fastened to the stand B by a screw G at the other end, and consequently the tension of the spring causes the drum to move backward after the twine e is relaxed. The action of the drum is, in fact, exactly like that of the drum of an indicator. A paper is wound around the drum and is held fast by the clamps $E\ E$, fig. 7, as on an ordinary steam-engine indicator. The tension of the spring can be varied at will by turning the sleeve F, which is provided with six holes, as shown in fig 7, to receive the screw G, by which the sleeve can be fastened in any desired position, to give the required tension to the spring.

Above the drum A, figs. 2 and 6, a sliding bar $f\ f$ is arranged to move in a guide g.* One end of this bar has a pencil p, and at the other end it is provided with a forked jaw, $i\ j$, to receive the end of a rod k, which is fastened by a clamp l to the valve-stem H. It should also be explained that the diameter of the drum A and the pulley C have the proportion of 5 to 9 to each other, so that in the diagrams which are made with this instrument, the stroke of the piston is represented as being only five-ninths of the actual stroke of the engine, whereas the travel of the valve is drawn equal to what it really is. The engravings are ½ of the full size of the diagrams.

From this description the operation of the instrument will be readily understood. If a sheet of paper has been placed on the drum, the movement of the cross-head will cause the drum to revolve, the motion of its surface being equal to five-ninths of the stroke of the piston. If during this revolution of the drum the pencil p was stationary, it would trace a straight line on the paper. The rod k, which is fastened to the valve-stem and is held between the jaws $i\ j$, causes the bar f and pencil p to move coincidently with the valve. Consequently the figure which is drawn by the pencil is an elliptical curve, the breadth of which depends upon the travel of the valve, which in turn is governed by the position of the link. These curves represent the movement of any and every point of the valve. A full explanation of these curves will be found in the book referred to by Mr. Cole, so that it is hardly necessary to repeat it here. The curves may represent the movement of any point of the valve, but in order to be able to assign them to some particular part, we must have a center line to lay off the steam-ports from. To draw such a center line the engine may be moved so as to bring the valve in its central position on the valve-face. Then by detaching the rod k from the jaws $i\ j$, and moving the engine, the pencil will draw a straight line, which will be the center line of the diagram ; or a line may be drawn with the valve-stem in any position, and then if by means of a tram, or in any other way, we can know how far out of the center the valve is, a true center line can be drawn on the diagram from the line which has been described. Having laid down such a center line as $M\ N$ in fig. 10, if we want to show the action of the valve during the admission of steam—that is, show how the steam-edge M of the valve moves in relation to the steam-port—we would first draw the valve V, so that its edge M will coincide with the center line $M\ N$ of the diagram. Then draw the steam-ports $P\ P'$ and exhaust-port X in the position they would occupy in relation to the valve when the latter is in the middle of its seat, and extend the lines which indicate the edges of the ports downward to the bottom of the diagram. Obviously the distances $M\ R$ and $M'\ R'$ of the lines $R\ S$ and $R'\ S'$ from the edges M and M' is equal to the lap of the valve. Knowing this, and the width of the ports and bridges, they may all be readily laid down.

The curve marked 1, 1, indicates the movement of the valve when it has its maximum travel, and those numbered 2, 3, 4, etc., its movement when the reverse lever latch is in the respective notches. Beginning at R, and we see that the portion of the curve from R to b shows that the valve has opened the port ¼ in., while the piston has moved 1 in., as indicated by the horizontal lines. At c, or when the piston has moved 4½ in., the curve shows that the port is wide open. With the maximum travel the valve "throws over the port" $\frac{1}{16}$ in., and begins to close it at d or when the piston has moved a little over 10 in. At e or at 18¾ in. of the stroke the port is entirely closed.

If we want to study the movement of the exhaust edge of the valve, a line $h\ g$ may be drawn at a distance from M equal to the inside lap. Then the horizontal distance of the curve $R\ b\ c\ d\ e\ f$, from the line $h\ g$, will be the same as the distance of the exhaust edge T of the valve from the inside edge $h'\ g'$ of the port P' during the whole stroke, and will show how wide the port is open and when it is closed, and, in fact, indicates to the eye the exact action of the valve in exhausting the steam during the whole stroke.

A study of the two diagrams, figs. 10 and 11, will show many interesting features, and shows very clearly the effect of increasing the travel of the valve. A curious feature is noticeable in the flat places on each side of the curves, which is due to the lost motion in the valve-gear, and shows that the pencil was stationary for a short period, while the movement of the valve was reversed.

As a means of studying the action of valves this instrument is a very valuable adjunct to the indicator, or perhaps it should be said that the indicator may be a valuable adjunct to this instrument.

The one which we have illustrated, as stated above, was designed by Mr. F. C. Cole, Mechanical Engineer of the Baltimore & Ohio Railroad, who says that "we have been able to take two diagrams from an engine applying and detaching the instrument inside of an hour." In making the diagrams the engine is run continuously, the reverse lever being moved at each revolution as the crank-pin turned over its center.

Metallic paper of the quality used for indicator diagrams is used on the drum, and a soft brass wire serves the purpose of a pencil. This is attached to a kind of sleeve, and rests by its own gravity on the paper.

In some experience with a similar instrument the writer found that the most convenient arrangement was to attach the pencil to a light spring which would lift the pencil clear of the paper. To draw a diagram the pencil was gently pressed with the finger, so as to bring it in contact with the paper. It can thus be instantly released when the diagram is completed, and is never in contact with the paper excepting during the time that the diagram is drawn.

* It will be noticed that the position of the instrument is reversed in these two figures.

PETROLEUM MINING AT MENDOZA, ARGENTINE REPUBLIC, SOUTH AMERICA.

RESULTS OF 12 WELLS WHICH HAVE BEEN WORKED—PETROLEUM USED IN PLACE OF COAL AND EFFECTING A GREAT ECONOMY TO THE RAILWAY COMPANIES USING IT.

One of the many mineral products found in the Argentine Republic during the last three years has been crude petroleum, which was first believed to be existing in the province of Jujuy, but after some $100,000 had been expended without favorable results to the mining company, it was resolved to abandon that province and try in the adjoining one, Mendoza, in which State, at a place called Cacheuta, in the department of Lujan, where recently the 12 perforations were made for petroleum and gave the following results :

Well No.	1, depth	110	meters.	Abandoned.
" "	2 "	103	"	Gave asphaltum.
" "	3 "	67	"	Good petroleum.
" "	4 "	90	"	Worked.
" "	5 "	103	"	"
" "	6 "	200	"	Spoiled by carelessness.
" "	7 "	70	"	No result.
" "	8 "	210	"	Hot water, sulphurous ; worked.
" "	9 "	210	"	Worked.
" "	10 "	220	"	Abandoned for want of material.
" "	11 "	104	"	Signs of petroleum.
" "	12 "	30	"	" " "

The wells Nos. 4, 5, and 9 are the only ones giving petroleum, and these are worked by means of a crank-wheel from the principal engine shed, the oil running through pipes to two large tanks in the hollow, which have a capacity of 200 c.m. From these tanks the crude matter is conducted through 5 in. pipes to the chief depôt, located at a small village called San Vicente, 1½ miles from the city of Mendoza, which is the terminus of two railways, the Ferro Carril Gran Oeste Argentino and Ferro-Carril Trasandino. Both of these companies use a great deal of the native mineral for their locomotives in place of coal, which costs at least $12 per ton. A large gas company established at Mendoza is one among other concerns utilizing the crude petroleum, which is similar to black tar.

The cost of laying the piping from well to depôt (where there is a tank which holds 3000 c.m.), at San Vicente, a distance of 42 kilometers (24 miles), was about $124,000 ; for three tanks, about $30.000 ; for working expenses, about $420,000 ; total, $574,000 (national dollars). The perforation of the wells must be added, which cost, more or less, $105 (paper money) per meter (39⅜ in.).

To meet the above expenditure and maintain workshops and erect houses for the workmen, about 50 in all, a company was formed with a capital of $1,000,000 (Argentine dollars) at Buenos Ayres.

As it is so styled, La Compañia Mendocina de Petróleo has an extent of about four square leagues (12 miles) of ground, and the works are at the foot of a spur of the Cordilleras de los Andes.

The price at which the petroleum is sold varies according to the money market, but the average rate is $12 in gold the cubic meter (cubic yard), or 55 cents per gallon. Since the first borings commenced at Cacheuta (Mendoza) over 2,000 tons of fluid have been produced, which seemingly made a difference in the figures of imported petroleum for the year 1891, when only 2,300,000 galls. of that oil was received in the Argentine Republic against 3,100,000 in 1888.

To illustrate the advantage of using petroleum as an engine fuel instead of coal, I will give an extract from one of my engine mileage and storage sheets (Argentine Great Western Railway Company) of two locomotives for one month. Engine No. 50 (running on coal and wood) traversed 683 miles, consumed 21,709 lbs. of coal, 1,550 c. ft. wood; oil and tallow, 117 lbs.; hauled 10.383 vehicles. Engine No. 51 (with petroleum fuel and little coal) ran 1,312 miles, consumed 8,593 lbs. of coal and 35,155 lbs. of petroleum, hauling 24,484 vehicles, consuming 174 lbs. of oil and tallow. In the following table is a *résumé* of averages upon each of the before-mentioned engines:

	No.	Average of		
		Coal per Mile.	Oil and Tallow per 100 Miles.	Vehicles Hauled per Mile.
		Lbs.	*Lbs.*	
Engine.....	50	31.78	17.13	15.20
"	51	6.82 26.79 Pet.	13.36	18.66

The above figures show very clearly the saving there is in having petroleum as fuel, and it will be worth the while of North American engineers and locomotive superintendents to turn their attention a little more to liquid fuel, which has been used with success on a few railroad lines in South America.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

The object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in September, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN SEPTEMBER.

Portsmouth, O., September 5.—A west-bound mixed train on the Cincinnati, Portsmouth & Virginia Railroad ran through an open switch at Beardon at three o'clock this morning, colliding with a work train on the siding. Fireman Robert Little, of the mixed train, was instantly killed, and the engineer, George Glasgow, was fatally injured.

Aurora, Ind., September 5.—A Big Four freight train came into collision with an express at Batesville this morning. The accident took place at the bottom of a steep grade six miles north of Aurora. The engineers of the two trains, Samuel Sheehy and John Winslow, were injured, both being cut about the hands and face.

Grass Valley, Cal., September 6.—A narrow-gauge train on the Nevada County Narrow-Gauge Railway, hauling Sells & Renfrew's circus, was wrecked a mile and a half from here this morning shortly after midnight. Daniel Coghlan, the engineer, had his hip sprained, and Joseph Duffy, the fireman, was bruised about the body. The train was proceeding slowly around a curve when the horses in a box car overbalanced it, derailing the train. The escape of the engineer and fireman was considered miraculous, as their engine was thrown upside down and they were thrown out.

Radnor, Pa., September 6.—A coal train ran into a freight train at this point this afternoon, completely wrecking several cars and injuring the engineer and fireman of the freight train. Track No. 1 at this point was being held by a passenger train which was delayed, owing to a hot box. The operator, not knowing that the passenger train had come to a standstill, had given the signal for the freight to go on to track No. 1. Before the freight had cleared track No. 2 the coal train came along and crushed into the rear of the freight. The engineer, Jacob Givens, was bruised about the hands and legs, while the fireman, Elias Lightly, was internally injured.

White Plains, N. Y., September 6.—Herbert Blake, a fireman on the shop train engine of the Harlem Road, fell from his engine as a train was coming out of the Fourth Avenue Tunnel at Ninety-ninth Street this evening. He rolled across the opposite track. The Saratoga express train narrowly missed cutting him in two. His skull and right leg below the knee were fractured, and his chances of recovery are very slight.

Colehour, Ind., September 7.—A collision occurred just south of this point on the Chicago, Pittsburgh & Fort Wayne Railway at 9.30 this morning, between a milk train and an east-bound passenger train on the Pittsburgh, Cincinnati, Chicago & St. Louis Railroad. The accident occurred on the Y running from the main line just south of Colehour to East Hammond. The fireman of the Pittsburgh, Cincinnati, Chicago & St. Louis train was internally injured.

Valparaiso, Ind., September 7.—The Valparaiso accommodation train on the Fort Wayne Railroad, which left here at 7.30, was run into by a fast passenger train on the Pan Handle Railway about 30 miles west of this city. The engineer and several passengers of the latter train are reported killed and 20 injured.

Dutton, Ont., September 8.—The fast express on the Michigan Central, for Chicago, ran into the rear of a freight train near this point this morning. The fireman on the express train was slightly hurt.

Easton, Pa., September 8.—Jacob Spencer, an engineer of a local freight on the Lehigh & Susquehanna Railroad, was struck by a Lehigh Valley shifting engine at Phillipsburg this morning, but escaped with a lame leg and bruises about the body.

Rockford, Ill., September 9.—Andrew J. Fair, engineer on the Chicago, Burlington & Quincy Railway, was killed near Hinckley this morning. His engine left the track near the switch and ran into a box car on the side track.

Mumford, N. Y., September 9.—The Lehigh Valley Railroad flyer, running over the Buffalo, Rochester & Pittsburgh Railroad, ran into a local freight train at 8 o'clock this morning. The engineer, Jesse Randall, was badly injured.

Woonsocket, R. I., September 9.—An engine hauling the Northern Express of the New York, New Haven & Hartford Railroad, broke a connecting-rod on the left-hand side of the engine just this side of Northbridge this evening. The adjacent parts of the machinery were demolished and the cab battered. The fireman, William Reall, jumped and sustained a compound fracture of the right leg.

Findlay, O., September 10.—At 6.45 o'clock this morning two freight trains on the Nickel Plate Road crashed into each other four miles west of McComb and two miles east of Leipsic Junction. The locomotives were wrecked and 40 cars piled in a mass of débris. John Davidson, engineer of the east-bound freight, was instantly killed, and his fireman, J. N. Umpher, with Engineer Charles Merritt, of the west-bound train, received fatal injuries.

Chestertown, Md., September 10.—When near Black's Station this morning, an eccentric-rod under an engine on the Baltimore & Delaware Bay Railroad broke, ramming a hole in the fire-box. George Byrnes, the fireman, to avoid being scalded, leaped from the train, which was running at the rate of 25 miles an hour, but was caught and dragged about 50 ft. Several ribs were broken and severe injuries received about the head, while his body was badly bruised, and it is scarcely possible he will recover. Engineer James Boggs leaped from the train and was badly bruised.

Chicago, Ill., September 10.—A World's Fair train on the Illinois Central Railroad ran into a switch engine standing on the track at Twelfth Street at about midnight to-night. The fireman of the Fair train and the engineer and fireman of the switch engine jumped and received no injuries. Oscar Griglass, engineer of the passenger train, stuck to his post and sustained a severe fracture of his right ankle.

LOCOMOTIVE RETURNS FOR THE MONTH OF JULY, 1893.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Av. Train. Passenger Cars.	Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Cost per Locomotive Mile. Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Cost per Car Mile. Passenger.	Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé	822	...	...	...	...	1,973,198	3,329	...	...	...	...	...	78.09	...	...	4.34	6.54	0.28	1.50	6.64	0.16	19.44	...	...	1.58
Canadian Pacific	614	...	561,959	716,338	607,332	1,885,629	3,071	...	...	...	...	...	62.70	...	...	3.26	10.03	0.31	...	5.65	1.28	20.55	...	...	3.17
Chic., Burlington & Quincy	541	...	...	...	...	1,579,580	2,919	5.78	18.75	...	...	...	75.27	...	...	4.63	5.07	0.23	0.16	6.67	0.05	16.81	...	...	1.25
Chic., Milwaukee & St. Paul	857	...	...	...	...	2,414,107	2,817	...	...	...	...	...	63.21	...	...	4.18	6.27	0.29	...	6.28	...	17.62	...	...	2.15
Chic., Rock Island & Pacific	...	...	617,922	947,905	382,848	1,948,675	...	...	...	54.96	72.19	36.04	59.51	...	...	2.50	5.46	0.26	2.50	5.92	0.41	14.55	...	...	1.96
Chicago & Northwestern	888	...	802,464	1,250,485	719,701	2,772,650	3,122	...	...	...	...	...	78.20	...	...	3.34	7.24	0.36	...	6.39	0.81	18.14	...	...	1.83
Cincinnati Southern	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cumberland & Penn.*	...	23	6,305	30,555	...	36,860	1,602	...	...	...	...	...	91.57	...	...	6.82	4.25	0.40	...	...	2.11	13.58	...	...	...
Delaware, Lackawanna & W. Main L.	211	196	...	...	...	655,099	3,342	...	...	...	...	...	86.28	...	...	3.16	6.85	0.49		5.93	...	16.43	...	...	...
Morris & Essex Division	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hannibal & St. Joseph	74	74	...	...	...	240,935	3,492	6.00	16.62	...	...	...	76.02	12.60	5.96	3.07	5.18	0.12	0.03	6.86	0.20	16.15	...	...	1.30
Kansas City, F. S. & Memphis	145	...	101,[illegible]	180,567	94,318	377,225	2,601	...	...	...	...	...	59.47	...	...	3.30	5.56	0.35	0.43	7.50	...	17.10	...	...	1.65
Kan. City, Mem. & Birm	42	38	37,[illegible]	39,635	15,340	92,274	2,428	...	...	...	...	...	54.60	...	...	5.27	3.05	0.25	0.36	7.01	...	15.94	...	...	1.06
Kan. City, St. Jo. & Council Bluffs	37	37	...	...	...	136,939	3,701	5.29	20.57	...	...	...	61.06	12.00	4.84	3.46	5.57	0.15	0.18	6.16	0.04	15.56	...	...	1.90
Lake Shore & Mich. Southern	599	...	511,421	705,614	469,026	1,686,061	2,814	...	...	56.72	81.55	35.01	60.50	...	...	3.12	4.62	0.16	...	6.87	0.20	14.90	...	...	1.52
Louisville & Nashville	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Manhattan Elevated	...	271	744,016	...	60,587	804,603	2,971	...	...	...	...	...	38.83	...	...	2.00	7.80	0.20	...	9.00	...	19.00	...	...	4.05
Mexican Central	148	115	...	...	...	359,694	3,127	...	...	...	...	...	69.42	...	...	5.94	13.36	0.51	0.21	4.85	0.84	25.73	...	...	4.28
Mil., L. S. & Western	112	...	90,724	135,664	65,633	301,021	2,687	...	...	...	...	...	73.62	...	...	3.70	8.85	0.16	...	6.13	0.94	19.78	...	...	2.45
Minn., St. Paul & Sault Ste. Marie	...	...	74,064	168,695	9,428	336,387	...	4.[illegible]	20.38	...	...	...	61.57	...	...	3.11	10.88	0.26	...	6.69	...	20.94	...	...	3.53
Missouri Pacific	333	...	...	...	...	1,059,564	3,531	4.42	16.15	...	...	...	...	...	...	4.65	5.42	0.33	1.17	6.25	1.43	19.25	3.87	1.45	1.88
Mobile & Ohio	107	82	76,044	141,382	55,331	272,757	3,325	...	19.60	...	...	...	57.98	...	...	2.10	4.10	0.22	0.65	5.80	0.97	13.84	...	...	1.42
N. O. and Northeastern	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
N. Y., Lake Erie & Western	...	619	469,906	848,150	280,899	1,618,955	2,615	5.10	22.60	87.90	126.50	73.45	95.61	17.[illegible]	5.60	4.96	6.00	0.38	2.30	7.28	1.18	22.57	...	...	1.96
N. Y., Pennsylvania & Ohio	...	255	167,074	403,910	148,035	719,019	2,855	6.10	18.40	69.50	115.50	88.75	89.56	11.40	6.30	4.10	5.48	0.30	1.84	6.81	0.99	19.52	...	...	1.15
Norfolk & Western, Gen. East. Div.†	...	...	133,391	268,794	53,738	455,923	2,714	5.00	21.20	45.14	116.27	...		9.20	5.50	5.90	3.90	0.40	...	...	...	10.20	...	...	...
General Western Division†	...	...	122,461	281,246	42,486	446,193	...	5.30	16.70	65.00	117.00	...	107.00	12.17	7.58	8.03	4.29	0.36	...	...	...	12.68	...	...	...
Ohio and Mississippi	118	...	143,411	135,818	88,733	367,962	3,256	...	...	...	...	...	71.12	...	...	3.24	2.79	0.25	1.27	5.36	1.58	14.49	...	...	0.77
Old Colony	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Philadelphia & Reading	...	...	487,076	304,962	927,965	1,720,003	...	...	...	...	...	...	74.90	...	...	4.62	4.55	0.36	..	5.86	0.42	15.81	...	...	...
Southern Pacific, Pacific System	730	670	684,758	843,762	291,571	1,820,092	2,717	5.51	14.11	...	...	...	64.83	...	...	4.96	16.81	0.22	2.25	7.26	1.13	32.65	...	.	5.22
Union Pacific	1029	..	659,693	1,076,102	355,072	2,090,867	2,032	6.07	17.32	...	...	...	90.01	...	...	6.57	8.65	0.21	0.97	8.10	1.24	25.74	3.90	1.84	1.91
Wabash	496	370	443,950	632,794	265,849	1,342,593	3,628	5.09	16.52	55.33	95.65	52.04	76.36	12.43	5.76	3.67	4.42	0.31	...	6.22	0.89	15.52	2.65	1.07	1.26
Wisconsin Central	150	119	127,900	191,355	60,799	380,054	3,392	...	...	...	...	...	71.55	...	...	2.10	3.46	0.21	...	7.22	...	18.39	...	...	2.32

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

St. Louis, Mo., September 12.—A switch engine exploded its boiler about 8 o'clock this morning in the Air Line yards, fatally scalding the engineer, Louis Laux, and Fireman James Smith.

Chicago, Ill., September 12.—Twenty masked men held up a Lake Shore train 150 miles from Chicago near midnight last night. After wounding the engineer, they blew open the safe of the express car. The engineer divined their motive, and grasping his coal pick, made a desperate resistance. One of the robbers was struck down and fell off the engine without a groan. Another came over the tender and in the dim light shot the engineer in the chest, seriously wounding him.

Philadelphia, Pa., September 13.—At noon to-day an out-bound express train on the Philadelphia & Reading Railroad crushed into a shifting engine at Tenth and Diamond streets, killing Frank Peters, the fireman.

Wheeling, W. Va., September 14.—A Baltimore & Ohio freight train was wrecked at Dillon's Falls, a few miles west of Zanesville, this afternoon. It was caused by a loose rail which had not been properly spiked down. The freight train was coming east at a fast rate when the bad rail derailed the engine, which was overturned, and 14 freight cars piled upon it. Engineer Fisher was instantly killed.

Minneapolis, Minn., September 16.—The engine and 14 cars of the first section of the east-bound freight train on the Chicago, Milwaukee & St. Paul Railway was derailed at an open switch at Olivia this evening. Engineer George W. Remsen and Fireman Charles Heddings were instantly killed.

Buffalo, N. Y., September 17.—Daniel Ryder, an engineer of a freight train of the New York Central & Hudson River Railroad, while backing his engine up to a water tank at Black Rock this afternoon was severely injured. He had his head out of the cab window, and it struck the water-tank.

Columbus, Ga., September 18.—Fireman George Wright was killed in a wreck on the Mobile & Girard Railroad, 1½ miles west of Troy, this afternoon. The engine and four cars, for some unknown reason, were thrown from the track. The engine turned over and fell upon the fireman. The engineer was stunned, and lay unconscious for some time.

Cumberland, Md., September 18.—William Shoemaker, a fireman on the Baltimore & Ohio yard engine, slipped from his engine to-day and sustained a fracture of the arm.

Bath, Me., September 18.—Al. Leavitt, an engineer on the Maine Central Railroad, had his face severely scalded by escaping steam to-day.

Newburg, N. Y., September 20.—The night train on the Lehigh & Hudson River Railroad was wrecked at Lake Grinnell this morning by running into a freight train. The freight train was run on a siding, but being a long one, its head end stood out on the main track. There were lights out but no flag, and the express train ran into it while running at the rate of 40 miles an hour. Seeley Weeden, the engineer of the express, jumped, and landing in the lake, was only slightly hurt. The fireman, Joe Dunn, was carried into the wreck and buried under some coal. He is very badly injured.

Nashville, Tenn., September 21.—A train on the Newport News & Mississippi Valley Railroad was held up at Fulton, Ky., this morning, by robbers. The engineer and fireman are reported as being killed.

Chicago, Ill., September 22.—About 1 o'clock this morning, Edward Polack, a fireman on the Alley Elevated Railroad, was told by his engineer to look out for some obstruction ahead. As the latter put his head out of the cab window he was struck by a passenger train. The entire scalp was torn off.

Kingsbury, Ind., September 22.—A freight train of the Wabash Railroad was side tracked here to allow two sections of the Montreal express to pass. The first section passed all right, when the brakeman on the freight train opened the switch, supposing his train was to go out on the main track again. Just at this moment the second section, running at 55 miles an hour, came along, and before the switch could be closed dashed through it and into the freight train. J. Green, engineer of the passenger train, was killed. The fireman of the passenger train had a leg broken and was severely burned. H. J. Vatkeney, the fireman of the freight train, was burned and scalded about the head, and bruised. John Whitaman, engineer of the freight train, had his right arm broken, and was badly burned.

Birmingham, Ala., September 22.—At 1 o'clock this morning, 19 miles north of this place, an attempt was made to wreck an express on the Queen & Crescent route, by removing a rail from the track. The engine, baggage car and mail car were demolished. Engineer Frawley and Fireman Waite were hurt, but not fatally.

Cumberland, Wis., September 22.—A rear-end collision occurred between two freight trains on the Chicago, St. Paul, Minneapolis & Omaha Railroad near this city this evening, in which Robert J. Orr, a fireman on the rear train, was fatally hurt. He jumped into the darkness just before the collision, striking on a bridge and cutting his head open. The engineer jumped, but was not seriously hurt.

Jessup, Ga., September 25.—A runaway engine on the Savannah, Florida & Western Railroad, starting from this place toward Waycross, ran into a freight train at the 63-mile post to-day. Both engines and several freight cars were wrecked, and the fireman of the freight train was seriously injured.

Wilmington, Del., September 26.—A boiler of a locomotive on the Philadelphia, Wilmington & Baltimore Railroad exploded to day, severely scalding Engineer Richard Beck and Fireman Samuel Alexander. The explosion occurred by the dropping of the crown sheet.

Bellevue, Mich., September 27.—An express train on the Grand Trunk Railroad, while standing at this station at 2 o'clock this morning, was run into by the Erie express. Fireman Jennison, of the Erie express, was badly scalded.

New London, Conn., September 27.—An engineer on the consolidated Road ran off the draw at Shaw's Cove this afternoon. The engineer failed to notice that the derailing switch was set against him. The track is laid on a trestle across the cove, and the derailing switch is placed at the edge of the land foundation on a curve. Three men were in the cab at the time and made a scramble for that side farthest from the water. The engine landed on its side deep in the mud, with its tender half over the cab. The three men were badly bruised and cut.

Sedalia, Mo., September 27.—A passenger train on the Lexington Branch of the Missouri Pacific Railroad had a narrow escape from destruction by running off of a trestle 5 ft. high half a mile west of that point. Between the ties on the east end of the trestle some one had placed a tie so that it projected above the rail nearly 3 ft. The engine struck it and was derailed, rolling down an embankment 8 ft. high and landing on its side. Engineer Patrick O'Connor and Fireman W. H. Finnell were injured.

Gulf Port, Miss., September 28.—A passenger train on the New Orleans division of the Louisville & Nashville Railroad ran into an open switch at this point this morning. It was running at the rate of 45 miles an hour at the time. An investigation shows that the switch had been properly set and locked, but that the lock had been burned off with a large pine knot and thrown away. The engineer and fireman were dangerously injured.

Hillsdale, N. Y., September 28.—A milk train on the Harlem Road was wrecked at this point to-day. Just south of this point the rails had spread, and the train rolled down a 50-ft. embankment. Engineer Ackert and the fireman, Joseph Anderson, jumped from the engine in time to save their lives. The engineer was badly bruised about the body, and received a severe scalp wound. The fireman was slightly cut.

Louisville, Ky., September 28.—There was a collision between a passenger and freight train this evening on the Knoxville & Cumberland Gap Branch of the Louisville & Nashville Railroad, near Hazelpatch, Ky. The misunderstanding of an order by one of the train crew is given as the cause. A fireman named Ryan was killed, and an engineer named Pierce had his leg broken.

Streator, Ill., September 28.—Two freight trains collided on the Chicago, Burlington & Quincy Railroad about 3 miles north of this city. Engineer William Gribble was killed. It was a head-on collision, and both engines were badly wrecked.

Phillipsburg, N. J., September 30.—A flue burst on an engine on the New Jersey Central Railroad about 6 o'clock this morning, filling the cab with steam, scalding the face and neck and upper part of the body of Joseph Lutz, the engineer, in a frightful manner. He is, however, expected to recover.

Our report for September, it will be seen, includes 40 accidents, in which 13 engineers and 14 firemen were killed, and 21 engineers and 19 firemen were injured. The causes of the accident may be classified as follows:

Boiler explosions	2
Broken connecting-rod	1
Broken eccentric rod	1
Bursting of flue	1
Collisions	16
Derailments	3
Falling from engine	2
Loose rail	1
Misplaced switch	1
Rail spread	1
Ran over derailing switch	1
Runaway engine	1
Shot by train robbers	2
Struck by obstruction	1

Struck by passing train	2
Train wrecked	3
Unknown	1
Total	39

TESTS OF THE NEW YORK AND WESTINGHOUSE AIR-BRAKE PUMPS.

Editor of the AMERICAN ENGINEER :

OUR attention has been drawn to a circular issued by the Westinghouse Air-Brake Company, called "A Comparative Test of the Westinghouse Air-Brake Company's 9½ in. Air Pump and the New York Air-Brake Company's No. 2 Duplex Air Pump." It is so at variance with actual results universally obtained with our duplex pump, that we repeated the tests under the same conditions, measuring the air, with three reservoirs, in the same way. The results of the tests were as follows:

Name of Pump and Size.	Duty required to raise the pressure from atmospheric pressure to 85 pounds per square inch in one cubic foot of space, pumps working against a constant pressure of 90 pounds per square inch in main reservoir; steam pressure 140 pounds per square inch.		Piston Travel in Feet, per Minute.
	Time per Cubic Foot of Air.	Steam per Cubic Foot of Air.	
The New York Air Brake Company's No. 3 duplex pump, two steam cylinders 7 in. diameter and two air cylinders, one 10 in. diameter and one 7 in. diameter ...	7.174 seconds.	1.881 lbs.	174
The Westinghouse Air-Brake Company's 9½ in. air pump. One steam and one air cylinder, each 9½ in. diameter	9.799 seconds.	2.774 lbs.	108.3

The test proves the New York duplex pump delivers 34 per cent. more air per minute than the Westinghouse 9½ in. pump. It also shows that the New York duplex pump delivers 46 per cent. more air with the same amount of steam. This is in accordance with the results which should be expected from the principle of construction of the duplex pump. The capacity of the two air cylinders is 50 per cent. greater than the capacity of the two steam cylinders. *Both air cylinders are filled with free air every stroke*, and this is delivered to the reservoir. The efficiency must, therefore, be 50 per cent. greater than is possible with the Westinghouse pump, as that can only receive one measure of air for one measure of steam.

If any different results have been secured with the New York duplex pump, it is because the pump was *out of order*.

The amount of heat developed in compressing air is in proportion to the rapidity of compression. A higher temperature might therefore be expected from a pump that compresses 34 per cent. more air in a given time. Our duplex pump was designed for a special purpose—namely, to furnish air for operating air brakes. In this service it is utterly impossible to generate sufficient heat to impair the efficiency of the pump.

Yours truly,

THE NEW YORK AIR BRAKE COMPANY.

PROCEEDINGS OF SOCIETIES.

Montana Society of Civil Engineers.—The regular monthly meeting of the Montana Society of Civil Engineers was held Saturday evening, October 14 Mr. Joseph H. Harper, of Butte, read a paper on the Butte smoke problem. Mr. Harper proposes to construct two main flues to convey the smoke and sulphur fumes to stacks, one located about two miles southwest and the other three miles northeast of the city. The cost of these flues and stacks would not exceed $500,000. Mr. Harper exhibited photographs of flues recently constructed by the Omaha and Grant Smelting & Refining Company, at Denver, in which porous terra-cotta lumber was used for the covering of the flue under what is known as the Lee patent. Mr. Harper believes that if these flues were constructed the smoke nuisance would be almost entirely abated.

American Society of Electrical Engineers.—In the October issue of the *Transactions of the Society* there is an article by Ralph W. Pope, on the advisibility of holding the monthly meeting at points scattered throughout the country rather than at the New York headquarters. The monthly meetings of the Association have been very successful and largely attended, and for several years there has been an increase of attendance. The plans which are followed by the American Society of Mechanical Engineers and other associations holding their meetings at different points throughout the country are cited, and it is now proposed that the country should be divided into sections, holding these meetings at different points. The article discusses the matter from all standpoints, and provides for matters of finance and the methods of work where it would be impossible for the writer of the papers, etc., to be present at the meeting. There is no indication as to whether the idea will be consummated or not.

Engineers' Club of Cincinnati.—At the September meeting Colonel Latham Anderson read a paper under the title Telford *versus* Macadam—Which was Right? which discussed the question of the best method of constructing broken-stone roadways. The essential features of a roadway of this kind, he said, were an unyielding foundation, thorough surface and under drainage, hard, tough stone for wearing surface, proper size of stone, and the thorough compacting of the materials. The paper discussed two of these requirements—the foundation and the covering—as contained in the practice of Telford and Macadam. The most important thing in connection with the foundation was the proper and thorough drainage of the subsoil by lines of tile drains 2½ to 3 in. in diameter, more or less in number according to the width of the roadway to be built, completely carrying off all the water and rendering the soil at all times dry and hard. A foundation of broken stone 10 in. deep on such a bed would carry the heaviest load that could come upon it in ordinary practice. The stone for the top surface should be clean, crushed in a mechanical crusher, and screened in a revolving cylindrical screen through holes of ½ in., ¾ in. and 2 in. sizes, the dirt and dust being rejected. The sub-grade should first be covered with a layer of 2½ to 3 in. of screened gravel. On this is spread and lightly rolled 6 in. of the coarser sizes of the stone, and on this the fine layer is spread and thoroughly rolled about 2½ in. in thickness. A moderate amount of sprinkling assists in consolidating the materials.

New York Railroad Club.—The October meeting was held on the evening of Thursday, the 19th, and the feature of the evening was a paper by Mr. D. L. Barnes, on The Construction and Inspection of Locomotive Boilers to Prevent Explosions. It was profusely illustrated by stereopticon views showing the various methods of staying and bracing, with the author's ideas of the proper methods to be employed. There were also numerous illustrations of exploded boilers, showing the effects of the sudden rupture. The author's idea of the probable cause of the disastrous effects of the boiler explosion is that the sudden lowering of the pressure due to rupture caused a large quantity of the water which was contained in the boiler to flash out steam and to be hurled violently against the side of the sheets and tubes. Of course there was no new theory advanced of boiler explosions beyond that the boiler was not strong enough to stand the internal pressure. He stated that the majority of locomotive boiler explosions was undoubtedly due to the overheating of the sheets as the result of low water. He advocated the use of a double welt butt seam for all horizontal seams of the shell, and condemned the practice of having stay-bolt threads in contact at the bottom of the threads. The paper concluded with a classification of boilers into three categories, which would indicate their probable condition, and also with rules for the proper inspection of the various classes. The paper was somewhat lengthy, and it was decided that the discussion should be postponed until the November meeting.

Engineers' Club of St. Louis.—The Club met at 8 P.M., on October 4, at the Club rooms, 19 members present.

Mr. E. A. Hermann read the paper of the evening on Bracing a Tunnel in Soft Material. A tunnel 1,435 ft. long was built at North Bend, O., near Cincinnati, about 1840, for the Cincinnati & Whitewater Canal. The material encountered was a mixture of river sediments containing considerable water, and causing some difficulties in construction. About 1863 the canal was abandoned, and the right of way purchased by the Cincinnati & Indianapolis Railroad, now a part of the Big Four system. In March, 1884, an extraordinary flood in the Ohio River nearly filled this tunnel with water, and after

it receded a short piece of the tunnel about 80 ft. long showed a deformation of its section, the side walls being slightly pressed in and the arch flattened, and this deformation threatened to increase. The difficulty was promptly remedied by the system of bracing shown on the drawings. No further movement of the walls of the tunnel took place after they were braced for the following three years, when the extension of the double track over this part of the railroad necessitated either an enlargement of the tunnel or a realignment of the railroad around it. The latter plan was adopted as the cheapest and most satisfactory of the two, and after its completion the track through the tunnel was abandoned. Discussion followed.

Mr. George S. Morison presented to the club a valuable report on the Nebraska City Bridge. Mr. Brauer presented drillings of the nickel armor plate. For the next meeting a paper by Mr. D. A. Moliter on Landslides was announced.

Engineers' Society of Western Pennsylvania.—A regular meeting of the Society was held in Pittsburgh on September 19. Forty-one members were present; six applicants were elected to membership. The Library Committee reported the addition of 67 volumes since its last report. The papers read at the June meeting on Gas and Gas Producers, by Walter E. Koch, and on The Effect of Suddenly Applied Loads upon the Tensile Strength and other Properties of Iron and Steel were fully discussed. Mr. Charles Hyde gave an interesting discussion on Water-Tube Safety Boilers, illustrating his remarks by a working model of the Hyde water-tube safety boiler. On September 22 and 23 the visiting French Engineers were entertained by the Society. On the 22d they were taken by railway to the Macdonald oil and gas field, and to the coal-mines of the Pittsburgh Consolidated Coal Company; on the 23d by steamboat to Homestead, McKeesport, and Davis Island Dam. Very many of the largest and most important steel works, electric plants, inclines, and street-car power-houses were also visited. On the evening of the 23d the members of the committees of the Engineers' Society and of the manufacturers of the city were the guests of the French Engineers at a dinner at the Monongahela House.

A MEETING of the Chemical Section was held on September 26, 1893. The subject of Standard Methods for Sampling and Analysis of Iron and Steel was discussed. Mr. James O. Handy read a paper on The Effect of Arsenic on Phosphorus Determinating in Iron and Steel.

Engineering Association of the South.—At the meeting of the Association, in Nashville, Tenn., September 14, Mr. W. G. Williamson discussed the relations between the City Council, the Board of Public Works, and the City Engineer; he concluded that in small cities the existence of both the Council and the Board causes needless complications, though in large cities the great amount of improvements makes the Board more efficient than a committee of the Council; that the Engineer should be appointed by the Board, but should not be embarrassed by their appointing any assistants; that orders to the Engineer should proceed from but one authority, and if these orders are contrary to the Engineer's judgment, he should be allowed to put his objections on record; and that it is not good economy to bind an Engineer to let work to the lowest bidder.

Mr. Walter G. Kirkpatrick's paper described a System of Triangulation for River Surveying. The field work consists of reading four angles at each of a series of stations on one river bank, the distance between the first two stations and that between the last two being measured with tape. The computation is simple, a connected series of *sine* proportions, so that the addition of logarithms is cumulative, each addition evolving the length of a line in the system. The platting is by chords, affording such a check that an error can hardly escape detection. The system is accurate and requires but little more work than the ordinary transit and stadia survey; the computation can be framed from the field notes, then all the logarithms taken from a table, then all the additions made and all the necessary sides evolved, with which the plotting proceeds in a connected chain.

Mr. J. S. Walker discussed the Roof Trusses in the World's Fair Buildings. Mr. Hunter McDonald described the methods and progress in sinking caissons 40 ft. under water, for the foundations of the Johnsonville bridge over the Tennessee River now under construction.

Society of Naval Architects and Marine Engineers.—A notice has been sent out from the office of the Secretary-Treasurer in Washington, that the first general meeting of this Association will be held in New York City at 10 A.M., November 16, at the rooms of the American Society of Mechanical Engineers, No. 12 West Thirty-first Street, and that the session will extend through Thursday and Friday, November 16 and 17. It is proposed that there shall be an inaugural banquet on Thursday evening. An earnest request is made that the inaugural meeting of the Society be fully attended in order that the papers presented may be discussed with a thoroughness commensurate with their importance. Certificates of membership have been engraved, and it is expected that they will be presented to the members before they meet. Among the papers are the following: Transatlantic Navigation, by Charles H. Cramp, President of William Cramp & Sons' Ship & Engine Building Company, Philadelphia, Pa.; Steel Ships of the United States Navy, by Theodore D. Wilson, ex-Chief Constructor, U. S. N.; The Development of Shipbuilding on the Great Lakes, by John F. Pankhurst, Vice-President and General Manager of the Globe Iron Works, Cleveland, O.; Notes on the Machinery of the New Vessels of the United States Navy, by George W. Melville, Engineer-in-Chief, U. S. N.; Coal Bunkers and Coaling Ships, by Albert P. Niblack, Lieutenant, U. S. N; Production in the United States of Heavy Steel Engine, Gun, and Armor Forgings, by Russell W. Davenport, Vice-President of Bethlehem Iron Company, South Bethlehem, Pa; Determination of the Approximate Dimensions of a Vessel to Fulfill a Given Programme of Requirements, by Joseph J. Woodward, Naval Constructor, U. S. N.; Comparative Performances of American and Foreign Freighting Ships—Our Superiority, by William W. Bates, late Commissioner of Navigation, Treasury Department; The Wetted Surface of Ships, by David W. Taylor, Naval Constructor, U. S. N.: The Influence of Speed and Weight of Machinery on the Determination of the other Elements of the Design of Steam Vessels, by John J. O'Neill, Naval Architect and Marine Engineer; United States Treasury Rules for the Inspection of Machinery and Boilers, by James T. Boyd, General Manager George F. Blake Manufacturing Company. Papers are also expected from the following gentlemen, but the exact titles have not been decided upon: Colonel Edwin A. Stevens, President of Hoboken Ferries; A. Cass Canfield, Member America's Cup Committee, New York Yacht Club; Joseph H. Linnard, Naval Constructor, U. S. N.

PERSONALS.

MR. THEODORE NICKERSON, who has filled the position of General Purchasing Agent of the Mexican Central Railway for many years, having resigned to attend to his personal interests, Mr. E. W. BAKER has been appointed Purchasing Agent, with headquarters at Mason Building, Boston.

MR. JOHN D. FOUQUET, Architect for the New York Central and West Shore railroads for the past 10 years, has withdrawn his services from these companies, and will hereafter practise at 35 Broadway, New York, making a specialty of railroad structures.

Manufactures.

General Notes.

Manchester Ship Canal.—It is announced that it is the expectation of the management of the Manchester Ship Canal to open it for traffic throughout its entire length by January, 1894.

The Baldwin Locomotive Works have received an order for 10 Vauclain compound locomotives for the Philadelphia, Reading & New England Railroad. Of these, seven are Consolidation freight locomotives, with high-pressure cylinders 13½ in. × 24 in., low-pressure cylinders 23 in. × 24 in., driving wheels 50 in. in diameter. They will weigh in working order about 128,000 lbs. The other three are passenger locomotives, with high pressure cylinders 12 in. × 24 in., low-pressure cylinders 20 in. × 24 in., and driving-wheels 68 in. in diameter; estimated weight in working order about 96,000 lbs.

SUMMARY OF REPORTS OF DETENTIONS TO TRAINS FROM DEFECTIVE MACHINERY,

Fiscal Year ended June 30, 1893.

Cause.	Total.	Div. A.	Div. B.	Div. C.	Div. D.	Div. E.	Div. F.	Div. G.	Div. H.	Div. I.	Div. J.	Div. K.
Air hose bursting and becoming disconnected	14	5	2	0	0	2	1	[illegible]	4	0	0	0
" pipe breaking	12	0	4	0	1	1	0	0	1	3	1	1
" pumps failing to work	58	9	22	0	1	2	1	6	5	[illegible]	3	0
" signal breaking	4	0	0	0	0	0	0	0	0	4	0	0
Crank-pins breaking	22	1	2	2	0	0	[illegible]	[illegible]	9	1	4	0
Cross-heads breaking	6	0	[illegible]	1	0	1	0	0	1	2	0	1
Cross-head gibs and bolts breaking	66	[illegible]	4	15	0	2	15	6	11	2	[illegible]	3
Cylinders breaking	[illegible]	[illegible]	[illegible]	[illegible]	0	2	0	2	0	1	1	0
Cylinder cocks breaking	2	0	1	0	0	0	0	1	0	0	0	0
" heads "	29	4	5	1	0	2	[illegible]	1	1	3	11	1
Driving axles "	22	0	2	2	0	2	1	6	6	[illegible]	0	0
" boxes "	4	[illegible]	[illegible]	1	[illegible]	0	0	0	0	0	2	1
" brakes and bolts breaking	5	0	0	0	0	[illegible]	0	0	[illegible]	1	0	1
" springs breaking	21	3	7	2	0	0	1	2	3	2	1	0
Eccentrics breaking	19	0	[illegible]	[illegible]	0	1	1	2	4	4	3	1
Eccentric bolts breaking	57	2	4	[illegible]	3	1	10	[illegible]	5	[illegible]	[illegible]	2
" rods "	24	0	3	1	0	2	4	1	[illegible]	3	1	2
" straps "	34	2	3	3	0	6	[illegible]	1	9	[illegible]	[illegible]	1
Engine truck axles breaking	4	0	1	[illegible]	[illegible]	1	[illegible]	0	[illegible]	[illegible]	1	1
" " springs breaking	12	1	[illegible]	2	1	1	[illegible]	0	0	1	3	0
Follower head bolts breaking	6	[illegible]	0	2	0	1	0	1	1	0	0	1
Frame breaking	24	3	2	5	4	3	2	1	0	0	2	2
Grate arrangements breaking	108	4	12	28	8	7	13	[illegible]	15	9	7	2
Guides breaking	5	[illegible]	2	[illegible]	0	0	1	1	1	0	0	0
Guide bolts and nuts breaking	20	0	5	2	0	0	3	2	6	0	2	0
" yokes breaking	2	1	0	0	0	0	[illegible]	0	1	[illegible]	0	0
Jenney couplers breaking	2	0	1	[illegible]	0	0	[illegible]	0	0	1	0	0
Lifting-shaft arms "	4	0	[illegible]	[illegible]	0	1	1	0	[illegible]	0	0	0
Link breaking	1	0	0	[illegible]	0	0	[illegible]	0	0	1	0	0
" hangers breaking	2	0	[illegible]	1	0	0	[illegible]	0	0	0	1	0
Main rods breaking	4	0	1	0	0	0	1	0	1	0	1	0
" rod gibs and keys breaking	8	2	0	[illegible]	0	[illegible]	2	0	3	0	1	0
" " straps breaking	36	2	5	4	2	0	7	4	5	5	0	2
" " strap bolts breaking	11	[illegible]	2	1	0	1	[illegible]	1	4	2	0	0
Packing rings breaking	13	2	1	0	1	0	0	1	2	3	0	3
Piston glands "	[illegible]	0	1	1	0	0	0	1	1	0	1	0
" gland studs breaking	33	0	1	6	0	2	3	2	2	4	[illegible]	4
" heads breaking	8	0	0	0	[illegible]	0	0	[illegible]	1	0	3	2
" keys "	15	0	3	1	1	0	0	2	2	2	3	1
" rods "	41	[illegible]	[illegible]	1	0	4	2	3	12	7	9	0
Pop valve studs breaking	3	0	1	0	0	[illegible]	0	1	0	0	0	1
Pulling bars and bolts breaking	12	3	2	0	0	0	3	1	1	1	0	1
Rocker arms " " "	14	0	[illegible]	1	0	0	[illegible]	2	3	[illegible]	3	0
" box breaking	1	[illegible]	0	1	0	0	0	0	[illegible]	0	0	0
Safety valves "	12	1	0	1	0	0	1	2	4	1	2	0
Side rods breaking	7	2	0	0	0	[illegible]	0	[illegible]	1	2	0	[illegible]
" rod steady pin breaking	1	0	[illegible]	0	1	0	0	0	0	0	0	0
" " straps breaking	12	1	1	0	0	0	2	2	2	2	0	2
" " strap bolts breaking	10	[illegible]	1	3	0	1	1	2	2	0	0	0
Spring hangers and bolts breaking	116	9	15	13	2	19	19	6	11	7	9	[illegible]
" rigging breaking	69	6	12	5	2	2	14	3	17	3	4	1
Steam chests bursting	37	5	5	1	0	1	1	0	7	4	13	0
" chest relief valves breaking	6	0	2	0	0	0	0	0	1	1	1	1
Tender castings breaking	6	1	1	0	0	1	0	0	3	0	0	[illegible]
" draft rods "	8	[illegible]	1	3	1	[illegible]	1	0	1	0	0	1
" truck axles breaking	3	0	0	2	0	0	0	0	0	0	0	1
" " springs "	3	[illegible]	1	0	0	0	0	0	1	0	1	0
Throttle packing blowing out	7	3	0	[illegible]	0	0	3	0	0	0	1	0
" rigging breaking	4	1	0	0	2	0	0	0	0	1	0	0
Tires breaking and coming loose	7	0	0	0	0	0	0	0	0	3	4	0
Tire bolts breaking	2	[illegible]	0	0	0	[illegible]	0	0	0	1	0	1
Valves breaking	4	[illegible]	0	1	0	0	0	1	0	0	1	1
Valve stems breaking	5	0	1	0	0	0	0	1	1	2	0	0
" yokes "	9	0	[illegible]	0	0	0	4	0	0	2	0	0
Water scoops breaking	2	2	0	0	0	0	0	0	0	0	0	0
Wheel centers "	5	1	0	1	0	0	0	2	0	0	1	0
" guards and bolts breaking	3	0	2	0	0	1	0	0	0	0	0	0
Whistles breaking	4	0	1	1	1	0	0	0	0	1	0	0
Miscellaneous	127	7	7	14	11	9	12	10	32	9	13	3
Totals	1,263	91	152	137	42	81	141	93	215	122	136	51

The Stow Manufacturing Company, of Binghamton, N. Y., inventors and manufacturers of the Stow Flexible Shaft, report that their trade up to October 1 shows an increase over that of the corresponding months of 1892. Considering the general depression, this perhaps should be satisfactory to them; but their expectation of doing 100 per cent more business in 1893 than in any preceding year will hardly be realized. During the past two months they have greatly improved their plant, adding largely to their boiler capacity, etc. They report a decided improvement in the October sales over that of the preceding month.

Edwin Harrington, Son & Company, Incorporated.—The partners in the old firm of Edwin Harrington, Son & Company, manufacturers of machine tools in Philadelphia, announce that they have sold their interests and formed a corporation composed of Mr. John A. McGregor, formerly Assistant Superintendent of the Brown & Sharpe Manufacturing Company, of Providence, R. I.; H. S. Haskins, M. H. Harrington and E. L. Harrington, of the firm of Edwin Harrington, Son & Company; M. J. Morrissey, Robert F. Scott and Roger Sherron, formerly with the above firm, and will continue the same under the name of Edwin Harrington, Son & Company, Incorporated, at North Fifteenth Street and Pennsylvania Avenue, Philadelphia.

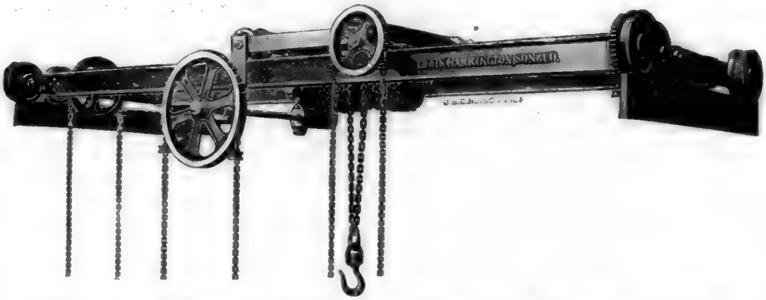
Underground and Overhead Railways.—A comparison has been made between the earnings and expenses of the underground road in London and the elevated line in Liverpool, which seems to show that the elevated road is the better paying investment. It cost very much less than the underground road, while its earnings per train mile are greater and its expenses per train mile less. The expense of the underground road, which has now been in operation for three years, is 13 cents a mile, while the elevated, which has been running but six months, costs but 8 cents. Some modifications of this must be made, however, inasmuch as the underground road has one more car per train, but still the earnings of the elevated road per train mile are greater by nearly 4 cents. For the first six months of 1893 the underground paid a dividend of three-fourths of 1 per cent. per annum, and for the last three months five-eighths of 1 per cent. per annum. Previous to this no dividends were paid.

A FOUNDRY CRANE.

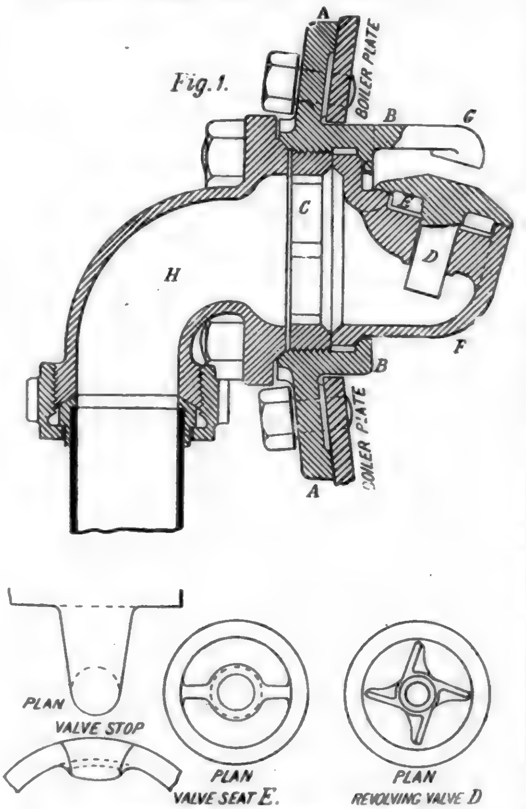
THE value of any hoisting apparatus for foundry or other fine work depends on its more or less perfect running. Thus, for the lifting of copes or molds the ordinary chain and sprocket wheel are almost useless. Made as carefully as possible, a chain running over a sprocket wheel will, as each link leaves its pocket, jar the load. The sand is liable to crack and the mold to break down.

With a view to obviate this difficulty, a new foundry crane has been designed by Edwin Harrington, Son & Company, Incorporated, of Philadelphia.

As will be seen by the engraving, the sprocket wheels of the hoist have been replaced by a drum having right and left spiral grooves, thus insuring the hanging of the hook always over the same point. There is no jumping or jarring; the movement is sure and steady, the chain winding and unwinding with the regularity of a rope on a windlass. Thus the cope can be lifted and lowered with no danger of the sand sifting out or mold "breaking down." The internal gears of this hoist are worked by means of a shaft extended far enough beyond the beams of the bridge to prevent the chain from interfering with the load, and this also enables the operator to stand at a respectful distance from a pot of melted iron.



FOUNDRY CRANE, BUILT BY EDWIN HARRINGTON, SON & COMPANY, INCORPORATED.



IMPROVED SAFETY CHECK VALVE.

The crane is operated by geared wheels throughout, and the shaft of the crane is placed inside the beam, thus saving room, and it moves the crane by pinions and intermediate gears, all of which are furnished with roller bearings, producing easy movement.

One of these cranes has been furnished to Messrs. Isaac A. Sheppard & Company, who have a foundry for the manufacture of stoves and hollow ware in Philadelphia. They say of it: "We are greatly pleased with the special foundry crane which you recently erected in our foundry. It is, in every way, perfectly adapted to the use for which it was intended, and lifts a mold absolutely without a jar, so that we have not had the least trouble with the breaking down of a mold at the critical point. For a light foundry crane we hardly see how it can be improved upon."

THE FOSTER ENGINEERING COMPANY'S IMPROVED SAFETY CHECK VALVE.

THE illustration, fig. 1, herewith, represents a sectional view of an improved form of safety check valve which the Foster Engineering Company, of Newark, N. J., have recently brought out. Little description is needed to make its construction clear. The valve is placed inside the boiler, the object being to place it out of danger or liability to injury in case of accident. In some of the most horrible accidents which have ever occurred on railroads, the injury to persons was largely due to the damage done to the check valves, which allowed the hot water in the boiler to escape, and which then scalded those exposed to it.

In the check illustrated, a ring, *A A*, is bolted to the boiler and surrounds the opening by which the check valve or its connecting pipe communicates with the inside of the boiler. This ring has a boss, *B B*, which extends inward through the opening in the boiler plate. The boss receives and holds a valve seat, *F*, which is inside of the boiler, and can be inserted or taken out through the opening in the ring *A A*. The seat is held in its place by a retaining ring, *C*, which is screwed into the outer ring. A valve, *D*, fits on the seat and can be removed with it. A stop, *G*, is attached to *B* and limits the movement of the valve. The feed pipe *F* is connected to *A A* by a neck, *H*, in the usual way. It is obvious that if this neck should be broken off that it would not disturb the check valve, *D*, and that if the water should escape from *F* the valve would close and hold the water in the boiler. In case of leakage the valve seat and valve can readily be removed and reground. Considerations of humanity should make the use of these valves or others equally effective compulsory on all locomotives.

THE MADDOX COTTON AND WIRE BELTING.

A NEW form of combination belting called the Maddox cotton and wire belting is now being introduced by H. N. Green, of 12 Wooster Street, New York. It is made of cabled soft steel wire and cotton woven solidly together, which makes it strong and durable. The cables of wire are each composed of six soft-steel wires twisted together like a cable, giving each separate one great strength. These cables are laid lengthwise in the belting about one-eighth of an inch apart, forming part of the warp, the cables composing about one-half of the warp; the rest of the belt being made of strong, tough cotton yarn specially spun for this work.

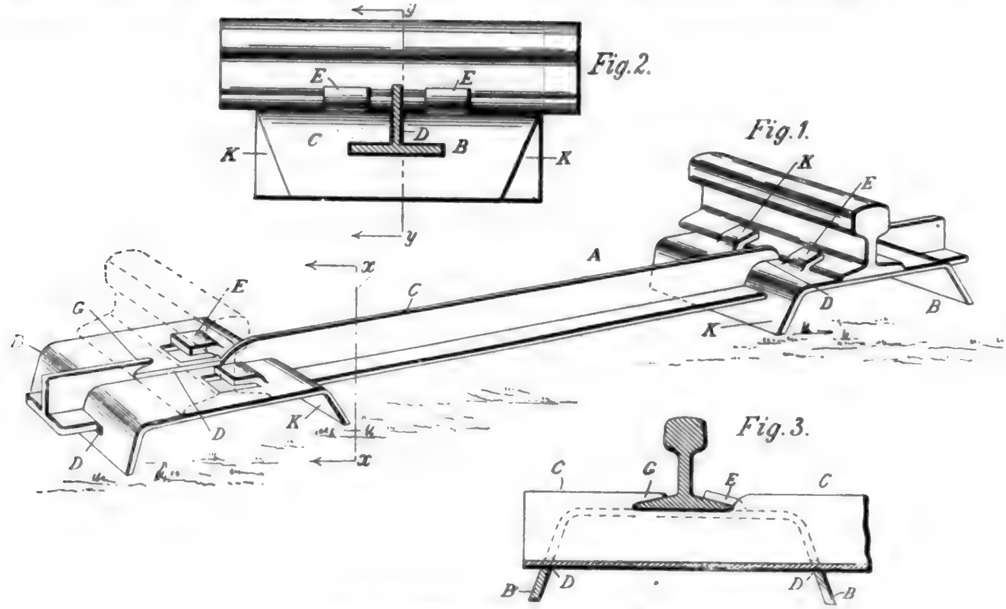
The cotton filling or woof is woven in solidly with the warp, there being no plies to pull apart. The process of weaving causes the wires to become corrugated in form with a depth about equal to the thickness of the belting. The belts are very flexible, and it is claimed that it is impossible for the

cables of wire to pull out. The weaving of the cotton and wire solidly together completely and thoroughly covers up the wires with the cotton, so that the wires do not come in contact with the pulleys at all, and cannot be seen in the belting except when it is cut so as to expose them. The rough surface given to the belting by the cotton forms an elastic face which prevents air cushions from forming between the belt and the pulley. It is claimed also that these belts can be run with greater amount of slack than ordinary leather belting, and that there is a consequent saving in wear and tear. It is waterproofed by being filled with a permanent water-proof material, and is said to be unaffected by water, steam, dampness, heat, moisture, dryness, oils, grease, acids or chemicals, or the vapors of any of them, changes of climate or water, dirt, dust, or other things which affect the ordinary run of belting. Furthermore, it will not rot, crack, mildew, or get hard and stiff, but always remain soft and flexible. It does not require grease, or oil, or other belt compositions. It is said to be especially valuable for use in paper and pulp-mills, chemical works, oil and sugar refineries, oil and soap works, tanneries, bleacheries, cotton, woolen, and other textile mills.

same time this flange bears against the shoulder on the tie shown just below *E* in fig. 3, which prevents the rail from moving inward. The ballast is then tamped in under the sleepers. To facilitate this, their inner flanges are cut away so as to have an inclined form, as shown at *K K*, fig. 2. The rail then bears on top of the sleeper and rests on its top face and also on top of the tie at *D*, fig 1. The lips *G* on the tie and *E* on the sleeper prevent the rail from moving either outward or inward, and the ballast can then be very conveniently rammed under the sleepers and under the bottom flange of the tie-bar *C*.

All the parts, it will be seen, are made of wrought iron; the ties are elastic in their nature, and from their form have an excellent support on the ballast. At the rail joints double ties are used so as to hold the rails more securely and give additional support to the sleepers.

The company named above, whose office is in the Betz Building, Philadelphia, propose to furnish these ties on long deferred payments, and think that they can show that it will be economical for railroad companies to substitute this form of permanent way for ordinary wooden ties.



THE COLUMBIAN METALLIC RAILWAY TIE.

THE COLUMBIAN METALLIC RAILWAY TIE.

The American Railway Maintenance Syndicate of Philadelphia have brought out a new form of metal permanent way which they are now prepared to supply to railroad companies, and which is shown by our illustrations, of which fig. 1 is a perspective view, fig. 2 a side, and fig. 3 a sectional view.

The structure consists of first, inverted trough-shaped sleepers, *B*, which are made in short sections and are placed below and support the rails. These sleepers are held in their proper lateral position by angle-iron ties, *C*. The sleepers are made of the form shown, with sides which flare outwardly so as to give ample space below them to receive ballast and have sufficient bearing surface for the support of the loads they must carry.

The upper faces of the ties have lips, *E*, which are punched out of the metal and bent upward so as to receive the flange of the rail, as shown at *E* in fig. 3. The sides and top of the sleepers have openings in them of the form of the angle iron tie-bar, as shown by the shaded area at *D* in fig. 2 so as to receive this bar. The top of the bar is notched, as shown at *D*, fig. 1, and has a lip, *G*, which hooks over the outside flange of the rail. In laying the rails the sleepers *B* are moved inward far enough to permit the outside flange of the rail to be hooked under the lip, *G*. The sleeper is then moved outward, and the lips *E* engage with the inside flange of the rail. At the

ROWELL-POTTER AUTOMATIC SYSTEM OF BLOCK SIGNALS.

For some time past this system has been in successful operation on the Boston, Revere Beach & Lynn Railroad, for use as a safety stop device in the protection of switches and a tunnel. On May 20 last it was also put in operation on the Intramural Railway of the Chicago Fair as a permissive system, and on July 31 last the absolute blocking was adopted. The essential features of the device are that if an engine runs past a danger signal a valve in the train pipe is opened and the air brake applied. The means used to accomplish this are very simple indeed. At each station there are three bars lying close to the rails which are very similar to the ordinary detector bar, and whose distance apart depends upon the traffic and the speed of trains. The central bar is attached to the signal, and when the latter is at safety it is raised up so that it would be depressed by the passage of the first wheel of the engine. As this bar is depressed the signal is set at danger and remains at that position until it is released and allowed to drop by an electric connection from the station beyond. When the signal is set at danger the other bars are raised, and they are connected with a simple arrangement outside of the track by which a stem or rod dropping down from the outer end of the buffer of the locomotive comes in contact with it and is raised. As this rod is raised it opens the valve in the train pipe and

immediately applies the brakes. It is probably the most extensive system of automatic stopping of engines on the block system that has yet been adopted, and its action on the Intramural Railway seems to show that it is a success.

There were 19 failures to operate on the Intramural Road during the time which it has been in operation, and taking this in comparison with the number of trains which have passed and number of movements which were necessary, it makes one in about 14,000 movements.

The device is being exploited by the Rowell-Potter Safety Stop Company, whose office is 117 Greene Street, Jersey City, N. J.

THE MANUFACTURING OF THE BOIES STEEL WHEEL.

THE Boies steel-tired wheel which is manufactured by the Boies Steel Wheel Company, of Scranton, Pa., presents some novelties in the method of its manufacture which will probably be of interest to our readers. A cross-section of the wheel is shown in fig. 1, and in this the center portion of the wheel is made of wrought iron with the steel tire shrunk on in position. It will be seen that there are only two parts to the wheel, and that the tire is thoroughly locked into and shrunk upon the center. The tendency of the rail against the flange is always to thrust the tire in toward the center of the track, and this is resisted in this case by the lip which projects up from the center and the one which comes down on the outside from the tire. The lock which is usually accomplished with a retaining ring is also used here, but is a part of the substance of the tire itself.

The method of manufacturing this center is exceedingly interesting. Selected scrap iron is first hammered down under a 15-ton hammer into round disks with a slightly increased thickness of hub at the center. Two of these disks are then raised to a welding heat and hammered together into the form of the center as it is used in the wheel. The heating is accomplished in a gas furnace, the gas being made on the premises by a special apparatus. Estimates of the expense show that for the same amount of work the expense of manufacturing the gas and using it as a fuel is but slightly in excess of what it would cost to use the coal direct, but that the results are very much better in cleaner and more substantial work. The hammering and forming of the center is done between dies, so that each wheel comes out practically perfect, and requires simply a turning off of the outer rim and a boring out of the hub before the tire is placed in position. The shrinkage which is allowed for the tire is of the regular master mechanic's standard of .01 of an inch to the foot in diameter. It will be seen that it is necessary to roll back the tire into the groove on the outside face of the center of the wheel; this is accomplished in the ordinary wheel lathe by a tool which is attached to the tool-post and is shown in fig. 2. The metal is spun down into the groove rather than being crowded or bent in. The tool consists of a roller held by a bar, which is in turn fastened in the tool-post of the wheel lathe, and the pressure which is brought to bear upon the overturned lip is that which can be obtained by drawing in on the screw of the cross feed of the tool carriage. It is possible to do this work in about 10 minutes, but owing to the desire to spin the metal out rather than bend it down, an hour is occupied in the work, the wheel making four revolutions to the minute. After this is done the tire is, of course, thoroughly locked in position, and when it becomes necessary to remove it the wheel is put in the lathe and this turned-down lip is cut off.

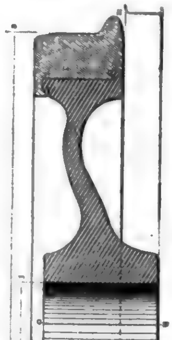


Fig. 1.

Experiments have been made with the rings which have been cut out of the metal, and they have shown that there is practically no change in the structure of the material in any way, and that it is fully as strong after being spun down into position as it was before that operation took place. The claim which is made for the wheel is that it uses the most suitable material in just the right place—that is, it has a soft wrought iron with fibers interlaced for the center and with steel tire for the tread.

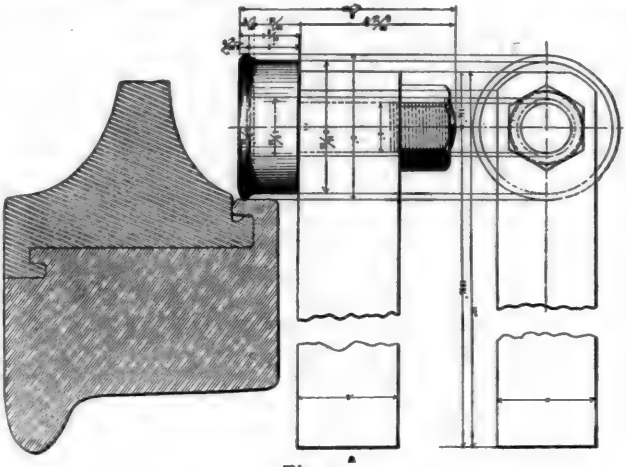


Fig. 2.

MANUFACTURING THE BOIES STEEL WHEEL.

Rifle for Canadian Volunteers.—The Martini-Metford rifle has been adopted as the future arm of the Canadian Volunteers. It is generally considered to be among the best of the single shooters, and to have some advantages over the magazine rifles chosen for the English Army. It has a small bore, and with so small a trajectory that it is fired point blank up to 500 yds.

The Tanite Company have sent us a box of their polishing paste for brass, nickel, zinc, and for the hot metal of fire and steam engines. As we do not run a steam engine in the office of the AMERICAN ENGINEER, we could not try it on such a machine. We are assured, though, that it will polish almost anything, from a brass kettle to the manners of a boot. It is said that it was tried on one of the latter who was in the habit of eating with his knife, picking his teeth at the dinner table, and chewing gum thereafter, and that now, owing to the effect of the tanite paste, he has abandoned all these bad habits and is a *polished* gentleman, who observes all the amenities of civilized life. We recommend our readers to try it on their steam engines if not on their friends who chew gum.

Wilmot & Hobbs' Oiler.—The Wilmot & Hobbs Manufacturing Company, of 20 Murray Street, New York, are making a copperized steel anti-rust oiler which is being received with a great deal of favor by engineers and others who have to do with the oiling of machinery. It is heavily copper plated inside, and is made of cold rolled No. 20 gauge steel. This steel has an exceedingly smooth surface, is rolled very accurately to the gauge, and is of uniform quality, free from scale and grit. The outside is so handsomely burnished that it perfectly resembles burnished copper. The sample railway oiler holds 2 quarts; it is 5 in. in diameter, 8 in. high, and is made from two seamless drawn parts. The nozzle is 1½ in. in diameter at the base, and may be made as long as 24 in. There is also another kind made in pint and quart sizes with 18-in. nozzles. These are heavily nickel plated over the copper.

The Joseph Dixon Crucible Company have authorized the publication of the fact that one of their commercial tourists, by his presence of mind in a recent railroad accident, saved a well-known clergyman from serious injury. The reverend doctor is the authority for the statement that the Good Samaritan mentioned in Scripture was a drummer, who, he says, had the *best* of oil and wine. It is not quite clear on what evidence this exegesis is based. Scripture tells us that a "certain man fell among thieves in Jericho," who "left him half dead," and that a Samaritan, "as he journeyed," had compassion on

him and administered oil and wine, and brought him to an inn, paid his bill, and told the host to take care of him, and "whatsoever thou spendest more, when I come again I will repay thee." The parallel is obvious. The Good Samaritan had wine, so have most drummers—often they have very "high" wine. The reverend doctor says that the Good Samaritan's wine was of the *best*. St. Luke is silent on that point. Is there not, perhaps, a little confusion here? It is hardly probable that the doctor would give testimony with reference to the quality of wine without some knowledge. As the Evangelist has given us no intimation about the quality of the contents of the Samaritan's flask, our reverend friend must have referred to that with which the Joseph Dixon Crucible Company's tourist was supplied, and which he (the tourist) may have poured into the injured person's—wounds. There is collateral evidence bearing on this point in the fact that the doctor says he woke "up about midnight with the bottom side of his coach in the direction of the stars." Pouring wine into wounds sometimes has this effect, especially when the wound is one which never heals up and is in the front and lower part of the face.

Other parallels are the circumstances that both the Samaritan and the tourist "journeyed;" they were both acquainted with the host of the inn; they both expected to come again—all of which is strong evidence that the Samaritan was a drummer. In two respects, however, the parallels fail—the scriptural account plainly indicates that the host of the inn was willing to trust the Good Samaritan. Would most hosts in this broad land of ours be willing to do the same thing for the generality of commercial tourists? Our clergyman friend tells us that "the drummer of Jersey City had the best of pencils"—manufactured by the Joseph Dixon Crucible Company—"and the kindest of hearts." In the latter respect he and the Samaritan—who probably represented some "house" in Jerusalem and had a customer in Jericho—resembled each other; but in the matter of pencils, no "concern" in Jerusalem can hold a candle to the Joseph Dixon Crucible Company, to whom the judges at the World's Fair have made awards for superior products in graphite, lead-pencils, plumbago, crucibles, black-lead stoppers and nozzles, dippers, bowls, foundry facings and lubricating graphite.

We would, though, like *fuller* information about the relative quality of the Samaratian and Dixonian wine.

THE TANITE COMPANY'S EXHIBIT OF ABRASIVES AT THE CHICAGO EXHIBITION.

In Machinery Hall, at Chicago, several emery wheel makers have full and interesting exhibits of a commercial character. The Tanite Company, of Stroudsburg, Pa., was requested by the Exposition authorities to treat "Abrasives" from an educational standpoint. The exhibit here illustrated and described is the result, and its compact character is due to the fact that the exhibit will be presented as a gift to the Smithsonian, the Chicago University, or some other suitable institution. While some of the articles were furnished by the Tanite Company, many were contributed by liberal-minded manufacturers.

Emery, being the most important abrasive, is illustrated fully. Emery ore is shown from Turkey, Greece, and the United States. In one piece clear blue sapphire can be seen with the naked eye. On a platter of pure aluminum are shown sapphires, corundum and emery, with the explanation that alumina is the oxide of aluminum, and that the articles on the platter are largely composed of crystallized alumina, the sapphire being almost pure alumina. Emery is then shown in its successive stages—first, as it comes from the crusher; then in the form of grain and flour; then as polish (powder, liquid, and paste); and, lastly, in the shape of whetstones and solid emery wheels. Fragments of various classes of tanite wheels are displayed to show the internal texture. There are bottles containing the dust gathered under tanite wheels after the grinding of cast, malleable, and wrought iron, and of brass and steel. These are for experimental examination with magnifying glass and magnet. "Petrified sparks" are an interesting feature. These are strangely shaped cones formed of the matter which fuses below an emery wheel when grinding under heavy pressure. The comparative products of the emery wheel, file, and cold chisel are tabulated on a framed sheet, while the case contains pieces of cast iron and saw-steel with the cuts made by file and wheel. The piece of saw-plate demonstrates that in a given time the wheel did 126 times as much work as the file. In the case and on the ends of the stand are numerous parts of machines, all of which have been surfaced by the Newman Emery Planer. These appear to be as true as if planed, and tabulation shows that this machine has taken a maximum cut one-quarter of an inch deep, and has taken a $\frac{1}{16}$ in. cut over a surface of 100 sq. in. in 6 minutes and 9 seconds. Its ordinary cut is from $\frac{1}{64}$ to $\frac{1}{32}$ in.

Emery wheels are usually thought of in connection with metal grinding, but in this case are shown blanks for long combs and ladies' back combs, made of vulcanite, and other samples showing that the long comb has been edged and the back comb had the spaces between the teeth cut out with tanite wheels. Glass guides from a silk-spinning mill are also shown. In these guides the silken thread wears a tapering groove which eventually breaks the thread, and these grooves are ground out by the use of tanite wheels.

As curious and instructive examples of abrasion, the parts of various machines used in the Tanite Factory are shown, all testifying to unequal and destructive wear due to unequal stress and the friction of emery dust.

Corundum is shown from Ceylon and from our Southern States, in the form of mineral samples, and also in grain. To the latter samples, as also to some of the emery samples, are attached analyses showing the proportions of insoluble corundum, of dissolved alumina, etc. Samples of pumice stone and of rotten stone are contributed by T. Van Amringe, of New York. Baeder, Adamson & Company, Philadelphia, show rock flint, or quartz, and rock crystal garnet, in rock, in grain, and on cloth. Norris & Brother, Baltimore, exhibit India spar. B. C. & R. A. Tilghman, Philadelphia, show chilled iron shot. The Pittsburgh Crushed Steel Company show a full line of samples of their so-called steel emery, and the Carborundum Company show that material rough and finished. Mill stone rock is shown by W. & F. Livingston and by Samuel Carey, both of New York. William M. Kirby, Pittsburgh, shows grindstone rock, as do also J. Westby, Levick & Company, Sheffield, England. J. B. Hull, Stroudsburg, shows, in regular order, the materials used in rubbing down granite and marble. Scythe stones, rough and finished, are displayed in great variety by P. M. Peterson & Son, Porsgrund, Norway. The Pike Manufacturing Company, of New Hampshire, also show a great variety of natural whetstones, etc. D. A. Richardson, Helena, Mont., contributes rough sapphires, and A. W. & C. E. Tanner, Red Bluff, Mont., some fine specimens of garnet. Corundum is supplied to this exhibit by Edward L. Hand & Company, Philadelphia, and by George L. English & Company, New York. Among the curiosities of abrasion are the following: Leaves of the Afeen plant, used to clean gourds, after the manner of sandpaper; contributed by Bolding Bowser, Esq., U. S. Consul, Sierra Leone, Africa. Wood of *Agave Polyacantha*, used for razor strops, contributed by William P. Pierce, U. S. Consul, Trinidad. Dutch rushes, or scouring rush (*Equisetum Hyemale*), from Yorkshire, England, supplied by David Brodie, M.D., London; and rush for same purpose, furnished by John Selwood, Stroudsburg, Pa. The epidermis of these plants is formed of silica, and the rush is used to polish wood and metals. Shark skin is contributed by the Tanite Company. This is to be used in same way as emery cloth and sandpaper.

Samples of carbon, or black diamond, and also samples of clear or gem diamond, suitable for turning or dressing emery wheels, are shown by the Tanite Company. The evolution of razors and table knives is shown in two series of samples, beginning in each case with the rough ingot or blank of steel, progressing through various stages of polish to the final bright finish.

An interesting series of photographs shows emery veins and mining processes in Westchester County, N. Y.

Two pictures are also exhibited: one of these seems to represent the tail of a comet, though what is really shown is the stream of fiery sparks streaming off from a Tanite emery wheel while engaged in grinding through a file. The other is a photographic reproduction of a picture in the Royal Gallery, Berlin. The photograph was contributed by Markt & Company, Hamburg, and the painting was by Gerard Ter Borch, who was born in Holland in 1617. This painting represents with much detail "The Grinder's Family," and depicts clearly the rough and primitive grinding processes then employed.

WORLD'S FAIR ROUTE.

The C. H. & D. Railroad have issued a handsome panoramic view, 5 ft. long, of Chicago and the World's Fair, showing relative heights of the principal buildings, etc.; also a handsome photographic album of the World's Fair buildings, either of which will be sent to any address postpaid on receipt of 10 cents in stamps. Address D. G. Edwards, General Passenger Agent World's Fair Route, 200 West Fourth Street, Cincinnati, O.

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

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EDITORIAL NOTES.

ALL subscribers to the AMERICAN ENGINEER AND RAILROAD JOURNAL should receive with the present number the Index and Title-page for Volume LXVII (Volume VII, New Series). Should any fail to receive it, they can have the omission supplied on notifying this office. The volume covered by this index includes the twelve numbers for the year 1893.

ANY subscribers who may wish to have their volumes for 1893 bound can do so by sending their files to the office, No. 47 Cedar Street, New York, by mail or express, prepaid, and remitting the sum of $1.25. The bound volume will be returned to them, at their expense, without delay.

Should the file be incomplete, the missing number or numbers can be supplied at 25 cents each. The amount required to pay for them should be added to the remittance for binding.

Any special style of binding or any lettering desired may be ordered, for which only the actual extra cost over the regular price will be charged.

AT the annual meeting of the American Society of Mechanical Engineers, which will be held this month, there will be presented the usual large number of papers of more or less practical value, interspersed with the social features for which the Society is so well known, the principal of which is a reception at Sherry's. In another column we give the list of the papers to be presented.

INTERESTED parties are naturally very much delighted over the performance of the cruiser *Columbia* on her trial trip, which occurred on November 18. The speed which the vessel attained and maintained, place her at the head of the list of sea-going vessels, and demonstrates beyond all peradventure the efficiency of the triple screw.

A PROMPT adaptation of one of the latest of American built vessels for use as an armed cruiser is witnessed in the recent sale and re-equipment of the steamer *El Cid* for service in the Brazilian Navy, and demonstrates the advantages to be derived by a country having a large fleet of merchant vessels available for such an emergency. The equipment of the vessel with the dynamite gun is also an interesting feature, whose action will be watched with the most intense interest by the whole civilized world.

CONSIDERABLE interest is being manifested in naval circles just at present over the fact that some of the vessels recently constructed for the Navy have been found to be so top-heavy, that it is necessary to lighten the weights above deck. In the case of the *Detroit*, for example, it is expected that it will be necessary to remove the conning-tower, possibly the ice machine, and probably put from 20 to 30 tons of cement on her bottom. The *Machias* and the *Castine* are in similar circumstances. It would seem to a layman that the ability which enables a constructor to design one of these ships should also lead him to a proper supervision of the calculations of her metacentric height, when ready not only for sea, but when ready to enter port with empty bunkers. We have a dim suspicion, however that when the contracts are let all of the work of the designer is not done, and that the weight of a great deal of the machinery is merely guessed at, and its center of gravity located by a still wilder guess. If such is the case, then there is small reason for wonder that the metacentric height of the vessel should be widely at variance from the calculations.

1894.

IT is usual at the close of an old year for editors to tell their readers what they intend to do during the next annual period which will be covered by the forthcoming volume of their papers. If they have any good things in store for their subscribers these are displayed in attractive typography, somewhat as Christmas presents are now shown in shop windows. The purpose in the two cases is obvious: the shop-keepers want to sell their goods, we want your subscriptions. The latter is the final aim and purpose for which we are editing and publishing a paper, to which the greater part of our thoughts, our time, and our efforts are devoted. It is, of course, desirable for an editor to have some new enterprises to offer to his readers at the beginning of the year. Last December we promised ours to give them a series of articles on English and American Locomotives. These have been completed, and while we expect to have much to say and more valuable information relating to the locomotives not only of America and of England, but of the whole world, than we have ever given them before, it will not be in a serial form, but it will be the latest information which is obtainable from all accessible sources.

The theory, the design, the construction and operation of locomotives have not yet reached a finality. Their defects indicate where improvement is needed, and no evidence has yet been submitted which indicates that those which are distinctly recognized are irremediable. There is hardly a branch of locomotive engineering in which there is not anxious inquiry for improvement. Their organs of combustion perform their functions as unsatisfactorily as the stomachs of dyspeptics or the livers of those who are bilious. Their breathing is often as difficult as that of a consumptive or asthmatic person, and their joints give as much trouble as those of a rheumatic patient, and there are more deposits of calculus in their reservoirs than there are in those of human beings. Their action is often as unbalanced as that of the mind of a human "crank," and they need direction and guidance, like wayward human beings. There is a constant demand, an effort

to improve locomotives, and it will be our aim not only to give the readers of the AMERICAN ENGINEER AND RAILROAD JOURNAL full information of the most recent improvements and the latest data concerning the operation of railroads, but also, by anticipation, to indicate the direction in which improvement is needed and may be looked for.

Compound locomotives we still have with us. Whether they are merely casual visitors, or have come as permanent residents, has, perhaps, not yet been quite definitely decided. In the columns of this paper these visitors will be hospitably received, and if, on further acquaintance, their characteristics entitle them to a permanent residence, they will be welcomed; but if they do not prove to be faithful and useful servants, they will be treated as aliens.

We hope to give much further data similar to that contained in a table published in our November issue, showing the defects in machinery which were the causes of detention of railroad trains. No more profitable investigation can be made by railroad men than to inquire into the nature and extent of such defects, which in so many cases are the causes which precede and produce serious accidents.

Our record of accidents to locomotive engineers and firemen will be continued. Its object is to call the attention of railroad managers especially, and the public generally, to the terrible amount of pain and agony, the suffering and bereavement and the sacrifice of life and limb which goes on daily on our railroads, almost unnoticed and certainly unheeded. We hope to awaken public indignation and to arouse railroad managers to the exertion of some intelligent effort to diminish this sacrifice of life, and the inexpressible torture to which men are often subjected for no other reason than that they have faithfully performed their duties.

It is our purpose during the coming year to give more attention than ever before to the design and construction of cars. We hope to be able to show especially how their weight may be reduced without lessening their strength, how their ventilation, heating, and lighting may be improved. For some thousands of years mankind has been engaged in sitting down, but it has been only within a few years that we have learned how to make proper seats, or one adapted to the human frame. Our efforts at reform in this direction will be continued.

All other kinds of railroad equipment will be discussed, and our chief effort will always be directed to giving our readers the latest information that can be obtained about the design, construction, and operation of all kinds of mechanism used on railroads.

The Contributions to Practical Railroad Information, by DRS. DUDLEY and PEASE, of the testing laboratory of the Pennsylvania Railroad, at Altoona, will be continued. They have been, ever since they were commenced, of increasing interest and value. A prominent railroad officer remarked during the past year that these "contributions" were the most valuable series of articles relating to the practical operation of railroads that have ever appeared in any paper, and—he continued—if railroad managers fully appreciated their value, they would place them in the hands of every subordinate officer who had anything to do with the use, the purchase, or the selection of materials on their lines. We take pleasure in saying that these articles will be continued for the greater part or the whole of next year.

The interesting series of articles on Progress in Flying Machines, by Mr. Octave Chanute, Past President of the Society of Civil Engineers, will be completed in the January number, and will be published in book form as soon as that is possible thereafter. During the past summer an International Conference on Aerial Navigation formed one of the series of "congresses" which were held in Chicago. The meetings of this Conference proved to be successful and interesting beyond expectation. Many papers were submitted and were read and discussed. These were placed at the disposal of the AMERICAN ENGINEER AND RAILROAD JOURNAL for publication. After due consideration it was thought that, as probably only a portion of the readers of that journal would be interested in the subject of aeronautics, it would hardly be fair or wise to devote as much of its space to that subject as would be required to give all of the proceedings at the Conference, or that portion of them which has special value. It was, therefore, concluded to print them as a separate supplement to the AMERICAN ENGINEER, and on October 1 the first number of such a publication was issued with the title AERONAUTICS, and will appear regularly each month for at least one year from that date. As a consequence of the publication of this paper as a separate journal, all matter relating to aeronautics will hereafter appear in it. The AMERICAN ENGINEER and AERONAUTICS will be furnished to subscribers in this country and Canada for $3.50, and in other foreign countries for $4 per year. The price of AERONAUTICS alone will be $1 per year for the United States and Canada, and $1.20 for other foreign countries.

It is thought that the publication of this journal, especially devoted to aerial navigation, will be more satisfactory to both those who are directly interested in this fascinating subject and also to those of the readers of the AMERICAN ENGINEER who are not.

The constantly increasing interest which is felt in the growth of our Navy and its armament will lead us in the future to devote much space to NAVAL CONSTRUCTION AND ORDNANCE. Many of the new ships have already been illustrated and described in its pages, and we will continue to give the latest and fullest information possible, with reference to the growth, the character, the organization, and the construction of the NAVY OF THE UNITED STATES, of which we all hope we may feel a just pride. The ships of foreign nations will receive due attention, and we hope to give in the AMERICAN ENGINEER such information as will lead those who are interested in our Navy to look to its pages for information.

TRAIN DETENTIONS.

To the Editor of the AMERICAN ENGINEER:

IN looking over the Summary of Reports of Detentions to Trains from Defective Machinery, on page 548 of the November issue, I find it both interesting and instructive, and being in tabulated form, very convenient for reference. I notice, however, that you have omitted items which, in my opinion, enter largely into what is termed "train failures," and I would be pleased to learn, if you have the information at hand, the number of trains operated from which you compute the table. Also whether records were kept, if any, of detentions due to boiler defects, such as leaky flues, defective fireboxes, or other boiler failures. I find no mention of these in the report referred to. By supplying this information you will greatly oblige MASTER MECHANIC.

NEW PUBLICATIONS.

THE THEORY AND PRACTICE OF MODERN FRAMED STRUCTURES. Designed for the use of Schools and for Engineers in Professional Practice. By J. B. Johnson, C.E., Professor of Civil Engineering in Washington University; C. W. Bryan, C.E., Engineer of the Edge Moor Bridge Works; and F. E. Turneaure, C.E., Professor of Bridge and Hydraulic Engineering in the University of Wisconsin. New York: John Wiley & Sons, 1893. Cloth, octavo, pp. xl., 527, with 38 plates. Price, $10.

This interesting and important volume is divided into two parts. Part I treats of the computation of stresses and the general theory of bridges. Part II treats of the details of construction and the processes of design, not merely of bridges,

but of trestles, stand pipes, and tall steel and iron buildings. Part I covers 232 pages, and Part II embraces 285 pages with the 38 plates. There are also 451 cuts throughout the text of the two parts.

The book opens with a brief account of the history of the development of American truss bridges, which is followed by six chapters giving the methods of computing stresses. This subject has been so fully treated in numerous other books that few points of novelty can be expected. Both analytical and graphical processes are presented, and the whole seems well adapted to the use of students. An analysis for stresses due to wheel loads by graphical diagrams may be especially mentioned. The discussion of conventional methods of treating train loads, by the use of excess weights and equivalent uniform loads, leads to the conclusion that no satisfactory equivalents can be stated which will give correct stresses for all parts of the truss, and that the actual wheel loads should continue to be used when they are prescribed in the specifications. The chapter on lateral and portal systems gives a fuller treatment than is customary in text-books.

Chapter VIII, on fundamental relations in the theory of beams, sets forth very clearly the conditions which exist when the material is strained beyond the elastic limit, and contains much sound doctrine. For instance, the statement that wrought iron and mild steel beams cannot be said to have any cross-breaking strength, will be novel to many engineers, but its truth must be admitted upon reflection. Next follows a chapter on column formulas, in which Professor Johnson cannot resist the temptation to propose a new one. This is similar in form to the well-known straight-line formula of Thomas H. Johnson, the square of the ratio of length to radius of gyration being used instead of the first power. The number of column formulas now proposed is so great that we think a halt might well be called in this line of progress, and the attention of investigators be more profitably directed to making experiments on columns when stressed within the elastic limit.

The chapter on suspension bridges, though short, deserves notice on account of a new theory regarding the action of stays, the author reaching the conclusions that the maximum unit-stresses in these are independent of their size and are greatest in stays nearest to the towers. In a numerical example this maximum unit-stress is found to be 64,000 lbs. per square inch, a figure sufficiently high to condemn the use of stays altogether, if the theory be true. These alarming conclusions are deduced by means of a principle in statics strange to us—namely, that when a structure contains superfluous members the load divides itself among the systems in proportion to their relative rigidity or inversely as their deflections. No demonstration of this is given, and the statement in a subsequent chapter that it is "nearly self-evident" cannot be accepted. The true principle to be used in this case is, we think, that the total work of all the internal stresses must be a minimum, and its application would probably produce a theory of stays more in accordance with known facts.

To continuous bridges only six pages are devoted, these structures being so little employed in America that it seems unnecessary, in the opinion of the authors, to teach the details of the practice. In the chapter on swing bridges, however, there will be found a good deal regarding the application of the principles of continuity. The five pages devoted to cantilever bridges does not well accord with the 16 given to arches, considering the greater interest and importance of the former class of structure. Chapter XV, on the deflection of framed structures, refutes the erroneous proposition of Stoney regarding the influence of web members, and gives examples showing that the distortion due to the webbing is nearly equal to that due to the chords. We are not prepared, however, to accept the statement that loads placed at the hip verticals have no influence on the deflection at the center of the truss, and, in fact, there are other points in the method which do not seem entirely satisfactory.

Part II opens with an excellent discussion of the conditions which determine the style of structure to be used, and this is followed by two chapters on the design of individual truss members and details of construction. These are controlling factors in building a good bridge, and hence are dwelt upon at length, numerous examples and tables of the Edge Moor standards being given. Then follow six chapters, in which are successively detailed the steps of design for a plate girder, a roof truss, a Pratt truss for a single track railroad, a highway bridge, a Howe truss, and a drawbridge. The designs are completed as far as computations and general plans are concerned, but detailed shop drawings and bills of material are not given, except for the Howe truss. It is, however, safe to say that nothing so thorough, clear, comprehensive, and reliable on bridge design has heretofore ever appeared in print. To students in technical schools, and to many older students in the offices of bridge works, the careful study of these pages will be of great benefit.

On timber and iron trestles, stand pipes and tanks, and tall building and mill construction, there are given many useful details of practice, as well as theoretical discussions. Literature on most of these subjects has heretofore been confined to the pages of periodicals and transactions of engineering societies. The chapter on mill construction is so excellent that we may perhaps overlook the fact that it is here republished for the third or fourth time, but we think that an effort should have been made to improve two almost illegible plates which accompany it. The chapter on æsthetics is a good one, and a move in the right direction which we heartily second; the pictures of European bridges are in general well chosen to illustrate artistic ideas, yet the æsthetic effect of the Wehra Bridge seems to us decidedly negative, while that of the Salzburg Bridge is mostly due to the beautiful castle in the background.

Besides the three authors whose names appear on the title page, chapters or parts of chapters have been written by J. W. Schaub, D. A. Molitor, C. T. Purdy, and G. H. Hutchinson. Appendices on specifications, inspection, and the erection of bridges are also furnished by F. H. Lewis, A. L. Johnson, and F. W. Skinner. Thus the book is the result of the thought and labor of many men, and while it hence lacks perfect unity, it presents subjects in different lights, and is particularly authoritative because each writer treats the topics for which he is best qualified by study and experience.

BOOKS RECEIVED.

Fifth Special Report of the Commissioner of Labor. The Gothenburg System of Liquor Traffic. Prepared under the Direction of Carroll D. Wright, Commissioner of Labor, by E. R. L. Gould, Ph.D. Washington, Government Printing Office. 253 pp., 6 × 9 in.

Sixth Special Report of the Commissioner of Labor. The Phosphate Industry of the United States. Prepared by Carroll D. Wright, Commissioner of Labor. Washington, Government Printing Office. 145 pp., 6 × 9 in.

Consular Reports, October, 1893, Commerce, Manufactures, etc. Washington, Government Printing Office. The reports in this volume, which relate to engineering subjects, are one on Canadian Canals, another on Bridges at Buda-Pesth, and a number of others on Technical Schools in Europe.

Second Report of the Bureau of Mines, 1892. Printed by order of the Legislative Assembly of Ontario.

Report of the Proceedings of the Twenty-seventh Annual Convention of the Master Car-Builders' Association, held at Lakewood, N. Y., June 13, 14, 15, and 16, 1893.

Practical Instructions Relating to the Construction and Use of the Steam Engine Indicator. Published by the Crosby Steam Gauge & Valve Company, Boston, Mass. 95 pp., 7 × 4¼ in.

Standard Tables for Electric Wiremen. By Charles M. Davis. Fourth edition, revised and edited by W. D. Weaver. New York, The W. J. Johnston Company, Limited.

A Field Book for Civil Engineers. By Daniel Carhart, C.E. Boston, Ginn & Co.

La Republique Orientale de l'Uruguay, Histoire Géographie, Mœurs et Coutumes, Commerce et Navigation, Agriculture. By Le Comte de Saint-Foix, Minister Plenipotentiary. Paris, Leopold Cerf, 13 Rue de Medicis.

TRADE CATALOGUES.

J. T. Connelly's Improved Mechanical Devices. Milton, Pa., 28 pp., 6 × 9 in. This pamphlet describes the special tools and appliances for putting in and taking out staybolts, which are manufactured by the publisher. It also describes a new car-axle lubricator and a new design of locomotive boiler.

Illustrated Catalogue and Price List of Engineering, Surveying, and Astronomical Instruments, manufactured by Seelig & Kandler, Chicago, Ill., 105 pp., 6 × 9¼ in. This catalogue describes the various kinds of instruments made and sold by this firm. It is quite fully illustrated, and

contains full descriptions and other data concerning the instruments which the firm has for sale.

THE ADDYSTON PIPE & STEEL COMPANY, Cincinnati, O., 8 pp., 7 × 9½ in. In this publication are given the weights of cast-iron pipe and standard specials made by this Company. An article from the *Railway Review* on the use of cast-iron culvert pipe is reprinted, and engravings and data concerning sewer and street castings are given. A description of the Addyston reversible road roller completes the work.

THE NEW YORK SAFETY STEAM POWER COMPANY. Catalogue A, Trade List No. 24, Vertical Engines. 51 pp., 7 × 10 in. This Company manufacture a type of small vertical engines which with their boilers are fully illustrated in the book before us. It is also announced that they are prepared to furnish several sizes of tandem compound automatic cut-off engines and Worthington's sectional safety water-tube boilers, all of which are illustrated and described.

THE BRUSH AS A FACTOR IN THE VARIOUS ARTS, with monographs by professional men of note. Issued by John L. Whiting & Son Company, Boston, 52 pp., 6¼ × 9¼ in.

This volume contains a number of short sketches relating in various ways to the manufacture and use of brushes. It is illustrated by a number of half-tone engravings of very beautiful pictures, presumably painted with the Whiting brushes. Some of the female figures shown are insufficiently clothed, but probably this is not the fault of the brushes.

CATALOGUE OF CAR HEATING APPARATUS. Safety Car Heating and Lighting Company, 160 Broadway, New York, 21 pp., 5¼ × 10¼ in. This book gives what may be called tabulated statements of the advantages of the system of heating cars, which is described, lists of the fittings used for the different systems, engravings showing the arrangement of pipes, illustrations of the Gibbs steam coupler, and general views of the end of a car and of a locomotive and tender showing the location of pipes, etc. A concise explanation of the principles and the construction of this system of heating would, it is thought, add to the value of the publication.

CATALOGUE OF FITTINGS OF THE PINTSCH SYSTEM OF CAR LIGHTING BY COMPRESSED OIL GAS. The Safety Car Heating & Lighting Company, 160 Broadway, New York, 55 pp., 10¼ × 6¼ in. This pamphlet gives first interior and sectional views, showing the application of the Pintsch system of lighting to a car. These are followed by 25 pages of detailed wood-engravings showing the different parts or fittings used in connection with this system. These illustrations are all very good, and each one is named and numbered. After these 18 full-page half-tone engravings of bracket, roof, end, and side lamps, are given, and the volume ends with sectional views of lamps with instructions for ordering gas equipment for railroad cars. The book is an excellent one of its kind; the engraving, printing, etc., are all of the best.

ARTIFICIAL LIMBS.—A. A. Marks, 701 Broadway, New York, has issued a new catalogue of artificial limbs with a statement by the judges of the Columbian Exhibition, granting him the highest award at Chicago in 1893. The first part of the catalogue is taken up with a full and complete description of the artificial limbs manufactured and their methods of application. It would appear from an examination of the cuts, that no matter what the amputation may be or what the physical circumstances attending it, the artificial limb can be applied in a way that will render walking and working easy. Furthermore, there is a naturalness about the gait of those using the foot that does not betray them to people who are unacquainted with the fact of their deformity, except that there is usually a slight limp, especially where there has been double amputation. We know of one or two instances in which there has been double amputation, and the wearers of these limbs go about with as much apparent ease as persons having their natural limbs, and attract no attention whatever except from the fact that there is a slight limp.

The catalogue gives full directions for measuring the stumps, and they can be fitted without the presence of the patients. There is one statement which will be of great interest to our readers, especially those railroad men who are liable to accidents involving an amputation, and that is that the maker recommends that the artificial limb shall be applied as soon after the healing and recovery as possible, because the stumps immediately after recovery from amputation tend to grow large and flabby, and the joints become inervated and the muscles have a tendency to contract. To counteract these tendencies bandages and massage have been recommended with thorough movement of the joints, to be persisted in until the artificial limb is applied. These limbs have been applied within one month after amputation, but this is usually too soon, a safe rule to govern the matter being as soon as the stump has become healed and the patient able to go about; then the limb may be applied. They specially recommend the use of artificial limbs to children, so that the development may be symmetrical and not one-sided. Numerous instances are given of applications, and the latter portion of the pamphlet is taken up with illustrations of men who are working and carrying on their ordinary vocations with artificial limbs.

MANUAL OF MODERN SURVEYING INSTRUMENTS AND THEIR USES, containing useful information for the civil engineer and surveyor, together with a catalogue and price list of scientific instruments, particularly those of the civil engineer and surveyor. Made by the A. Lentz Company, San Francisco, Cal.

The pages of this book are not numbered, and it would take too much time to count them. They are of a usual size, 6 × 9¼ in. It is somewhat more than a trade catalogue. As stated in the preface, "the details of every instrument are carefully enumerated and the functions of every part minutely described, so that the little book really becomes a pocket companion for the engineer."

Part I contains a description of the establishment, showing views of the interior of some of the special tools and machines used.

Part II deals with the manufacture of engineering instruments, their uses, repair, adjustments, etc.

Part III contains a number of professional papers written by well-known men.

Part IV is a price list.

The illustrations are most of them fairly good half-tone engravings. The book is very neatly printed, and a useful reference friend for the engineer.

ALUMINUM DRAWING INSTRUMENTS.—Messrs. Theodore Alteneder & Sons, of Philadelphia, have issued a supplemental sheet to their catalogue, in which they say:

"We occasionally receive inquiries for drawing instruments made of aluminum, and are called upon to answer questions as to the desirability of such instruments. We are now in a position, after years of experiments and tests, to state that instruments of any delicacy, or which have joints or wearing surfaces, made of this metal or any alloy containing it in sufficient quantity to have an appreciable effect upon the weight, are inferior in stiffness and wearing qualities. We do not offer such instruments to our customers, and always advise against their use.

"Pure aluminum is very soft, it possesses no wearing qualities, it is readily bent and cut, and its surface is easily rubbed or worn off, being somewhat like lead in these respects. Alloying it with silver, copper, and various other metals somewhat improves it, but not until the percentage of the latter neutralizes the advantage of light weight claimed for it.

"We do not admit that this is an advantage in drawing instruments, but maintain that our regular make are as light as is consistent with the proper feel and touch in their most efficient manipulation.

"In surveying instruments, which have to be carried in the field, lightness is an important consideration, and aluminum is perhaps used to some advantage, but never for wearing surfaces, working screw threads or bearings, these parts being always made of brass or other hard metal, or bushed. Any attempt, in drawing instruments, to use other metal for the joints, wearing surfaces, nuts, clamps and working screw threads, with aluminum for the larger and more passive parts, would so enlarge the instruments as to defeat the very object in view, and the result would be an inferior instrument at a greatly increased cost.

"The surface of aluminum is so easily abraded that it soils the hands and paper; it has also a greasy, unpleasant feel which becomes very objectionable. The patent joint of our dividers, if made of it, would soon wear loose and could not be tightened because the yoke, from want of stiffness in the metal, would spread even worse than poor quality German silver; the knuckle joints would soon wear loose and the strain on the screws for clamping the lead, needle points, and movable parts would result in the thread wearing out very quickly or stripping.

"In the course of our experiments we have discovered that the addition of a small percentage of aluminum to our present metal makes it whiter and perhaps stronger, and materially improves the surface by causing it to take a higher finish with a little less liability to tarnish.

"We make triangles of aluminum, and can recommend them as being accurate, light, and reliable; to overcome the objectionable feature of soiling the paper, we coat the surface with silver. We also make ruling pen handles of an alloy of aluminum and silver. In both these cases the metal takes the place of wood, and they are the only ones that we have found in which the lightness of the metal could be utilized to any advantage, or in which its use was not a positive detriment."

NOTES AND NEWS.

Telephone Wire.—A new kind of wire for telephone use, having an aluminium-bronze core with a copper-bronze envelope, is being experimented with in Germany. It is said to have a low resistance and great tensile strength.

Japanese Railroads.—The Japanese Government has in hand plans for the construction of 14 new railway lines. At present the railway mileage of the empire is about 1,500 miles, of which 994 belong to various companies. It is proposed that these shall be taken over by the State.

A New Trans-Alpine Tunnel.—Everything is about ready for the beginning of the work upon the Simplon tunnel. The conditions of the contract are that the tunnel, with a single line of rails, shall be ready for traffic in five and one-half years, but it is to be so constructed that it may be widened for a second line in four years more. The cost of the first enterprise is estimated at a little more than £2,000,000. The construction of this road will render the present pass superfluous. The road over this pass is the one which was constructed by Napoleon in the early part of the century at a cost of £720,000.

St. Louis Bay Drawbridge.—One of the latest propositions for spanning St. Louis Bay at Duluth, is that of a bridge with a span of 1,604 ft., 585 ft. of which is taken up for the approach grade on both sides, leaving the bridge proper 1,019 ft. in length. The draw-span is to be 444 ft. less the diameter of the turn-table mechanism. The projected bridge crosses between the points at their nearest limits, which is below the existing railroad bridge.

Electric Railway under Paris.—An underground electric railway from the Bois de Bologne to the Bois de Vincennes, in Paris, is projected. It is to consist of a circular cast-iron tube 20 ft. in diameter and 7 miles long, in which a double track will be laid. Trains of four cars will be run on each track at intervals of two minutes. Stoppages will be at 17 stations, and the distance will be traversed in about 45 minutes. Four thousand H. P. will be used for generating the electricity.

Railway to Victoria Nyanza.—In spite of the representations as to the probable impossibility of the railway to Victoria Nyanza paying a dividend, a report on the survey has been presented to the British Parliament. The estimated length of the railroad is 657 miles, the cost being at an average of $17,000 per mile. The report makes an elaborate estimate as to the probable amount of exports and imports and passenger traffic, and concludes that at the outside the road would be able to nearly pay its working expenses.

Turbine Wheels for Niagara.—The turbine water-wheels which are to be used in the Niagara Falls power plant are constructed with one wheel above the other, each 6¼ ft. in diameter and 18 in. high. Between the two there is a huge penstock which is 7½ ft. in diameter, which revolves both wheels simultaneously on a tubular shaft. The upper end of the shaft is connected directly with the dynamos at the top of the pit. The turbines operated in this form are kept balanced by the force of the water feeding them above the bottom step or stool of the shaft, and thus there is no danger of the shaft getting hot and burning out.

Mortar in Frosty Weather.—In a recent issue of *Le Génie Civil* M. Charles Rabut, Engineer of the Western Railway of France, deals with the question of handling mortar in frosty weather. Having tried mixing alcohol and marine salt with the water, he has now finally adopted common soda, which gives good results in reducing the liability of the mortar to freeze. One compound of soda reckoned in its anhydrous state is used per gallon of the water with which the mortar is mixed, and the increased cost due to its use is said to be about 37 cents per cubic yard of masonry, an amount which is often small when compared with the saving effected by avoiding a stoppage of work. The use of the soda causes efflorescence in the walls of the building, but the white blotches thus arising disappear after some months.

Kenka-Hebler Projectiles.—Further data has recently been received from Germany regarding the Kenka-Hebler tubular projectiles. The new data is obtained from bullets fired from a 5 mm. Hebler rifle. The ballastic data for various distances are as follows:

Distance, yards.	V. f. s. feet.	P. inches.
0	2,966	33.14
547	2,769	34.45
1,094	2,585	34.78
1,640	2,417	34.12
2,187	2,257	33.14
2,734	2,106	30.84

The penetration in inches is given against deal.

Novelty in Electric Lighting.—A new method of electric lighting is to be tested in a New York building, and instead of arranging the incandescent lamps on one circuit and feeding them continuously from the same source, they are arranged on a number of separate circuits, say, four, and the current is alternately switched from one to the other in regular succession, the idea being that the circuit, having heated each successive circuit of lamps to incandescence, will be returned again to that series before the lamp filaments have time to cool. The means by which this is accomplished is the employment of a special interrupter or rotary cylinder, on which the segments are so arranged that a system of brushes, with which they make contact, carries the current alternately to each series of lamps. The periodicity of the current in this device is about 70 per second.

High Temperature Pyrometers.—At the recent meeting of the British Association Callendar's platinum pyrometer was an exhibit of much technical interest. The difficulty of reading high temperatures, such as that of a furnace, has led to the employment of an electrical method, in which the temperature is determined from the change of electrical resistance of a platinum wire when exposed to the high temperature. Mr. Callendar finds that the law of increase of resistance remains simple and constant for the extremely wide range of temperatures included between the temperature of liquefaction of air and that of a blast furnace. Dr. Müncke, of Berlin, sent some samples of mercury thermometers for high temperatures (up to red heat), the advantage of mercury being its extremely regular expansion, so that the thermometer degrees are all of the same length. To prevent the mercury from boiling it is contained in a tube with carbonic acid gas under a pressure of 20 atmospheres. In the chemical laboratory Messrs. Baird & Tatlock exhibit a thermometer for the same purpose, in which the liquid used is an alloy of potassium and sodium. It can be used up to 600°.

The Automatic Balance of Reciprocating Mechanism.—In a paper on this subject, read before the British Association by Mr. Worby Beaumont, it was pointed out that in most cases of vibration in machinery, whether of rotary or reciprocating forms, the vibration was due to the restriction of the motion which would naturally occur if the nominally stationary parts were free to act under the influence of the disturbing force. To bring about such restriction and to prevent the movement of the stationary parts it was usual to balance the moving parts with care, and in most rotating mechanism this could be done with success. It was, however, very difficult in reciprocating mechanism, and in many cases could not be achieved. Troubles brought about by vibration might be completely avoided, and at the same time the strength, cost, and power hitherto necessary might be all reduced by completely reversing the usual proceeding. The unbalanced motor parts were automatically balanced by setting up as much motion in the thing to be moved as was necessary to absorb the inertia of motion or the momentum of the unbalanced thing in every part of its path. All vibration of the supporting parts is thus avoided, and that which usually sets up vibration is converted into a vibromotor. The paper was illustrated by working models.

Palleograph.—This is the name given to a newly invented German apparatus founded on the principle of so hanging a weight that, in consequence of its inertia, it takes no part, in a given direction, in the tremblings and oscillations of the point to which it is suspended. In a series of experiments with this device, made on board a twin-screw vessel of the German

Navy, it appears that the vertical vibrations always attained their maximum when the horizontal were at their smallest, and *vice versa;* this phenomenon was peculiar to twin-screw vessels only, and is explained by the difference in the number of the revolutions of the two engines and the reaction of the masses of the moving parts. The horizontal direction was exactly the reverse, and the action of the masses of the heaviest moving parts of the engines—the connecting rods and cranks—neutralized each other because they were of equal size and acted in opposite directions. The older passenger steamers had much smaller dimensions, and the engines, as is well known, ran at much smaller speed than those of to-day. The smaller the length of the ship, the greater the number per unit of the time of its vibrations. With the increase of dimensions, the period of the vibrations became steadily longer, while necessarily greater engine power, which was requisite, compelled the increase of the number of revolutions.

Steam from Molten Slag.—An Australian paper claims that an arrangement has been advised by which the waste heat of molten slag can be utilized. The machine used for the purpose consists of a steel shell in the form of an egg-ended receiver, having flattened faces on the top and bottom. Through these flat portions a number of boiler tubes arranged in two rows and tapered are passed and secured to the heads by flanges. The lower or larger end of each tube is closed by means of a cast-iron door manipulated by means of a lever. The upper end is provided with a funnel for convenience in pouring the slag into the tubes. The boiler being filled with water to the required level, the slag is poured into the tubes at once just as it comes from the furnaces. As soon as the tube is filled the first tube is emptied by releasing the lever which holds the door, and a conical cast of the cool slag drops into the truck below. As the tubes are emptied they are refilled with molten slag, and in this manner the work is conducted. It is claimed that at the conclusion of a 72-hour test the boiler was emptied and the tubes and all portions of it were carefully examined. The most minute examinations failed to show the slightest action, and the boiler was filled and tested hydrostatically, an ordeal which it is said to have sustained. There is no report given as to the dimensions of the boiler, the size of the tubes, or the length of time in which the molten slag is allowed to remain in position.

Electrically Controlled Clocks.—Herr F. von Hefner-Alteneck, in the *Electrotechnische Anzeiger*, makes a provisional statement about a system of electric control of clocks which appears likely to solve this much-attempted problem in a satisfactory manner. The main difficulty up to the present has been the necessity for a special wire system, central station, and attendance, the cost of which could not be defrayed by the limited public likely to require a luxury of this sort. Whenever, on the other hand, an enterprise was started with faulty mains and insufficient staff, the system was doomed to fail and to create a prejudice against the principle itself. All these difficulties are avoided by incorporating the control system with the electric light or power installation already existing. This is done by means of a clock invented by Herr von Hefner-Alteneck, which is placed in circuit like an ordinary incandescent lamp. It is kept wound up by the current, at an annual cost not exceeding that of one 16-candle lamp burning for 10 hours—*i.e.*, about *4d.* In case of interruption of circuit, the clock will go about 12 hours independently of the current. The control is effected once a day by a momentary drop of the circuit potential by about 6 or 10 volts at 5 A.M., which has the effect of pointing all the clocks in the circuit at 5. The effect upon the lamps is inappreciable. The control can be performed by hand in the dynamo room, or automatically through the assistance of an observatory. The General Electric Company of Berlin proposes shortly to embody the system in its enterprises.—*Nature.*

Railways of the United States.—According to the advanced sheets of the report of the Interstate Commerce Commission for the year ending June 30, 1892, there was at that time 171,563.52 miles of railway in the country, of which 3,160.78 miles was constructed during the fiscal year. The total number of locomotives was 33,136; of these 8,848 were passenger, 17,559 freight, and 4,355 switch engines, leaving 2,374 which were unclassified and leased. The total number of cars reported by carriers as their property was 1,215,092; of these 966,998 were in the freight service. The average number of locomotives per hundred miles of line is 20. The average number of passenger cars for the same distance is 18. The average number of cars in the freight service is 708. There was an increase during the year in the number of locomotives and cars fitted with automatic couplers and train brakes. The report shows a total increase in equipment of 27,139, an increase in the equipment fitted with train brakes of 68,537, and an increase in equipment fitted with automatic couplers of 75,299. The capitalization is placed at $10,226,748,144. The total number of passengers carried by the railways during the year was 560,958,211. The ton mileage was 88,241,050,225. The report shows that the number of passengers killed was largely in excess of those killed during the previous year.

The Peruvian Trans-Andean Railway.—The Central Peruvian Railway across the Andes has lately been completed to Oroya, the terminus originally intended, which is 30 miles beyond the summit. Our Consul at Callao, in his latest report, gives some details of this remarkable engineering work. It starts from the level of the sea at Callao, and crosses the Andes range to Oroya, 136 miles from the coast. At the seventh mile it is 500 ft. above the level of the sea, at the 18th, 1,300 ft., and at the 33d, 2,800 ft. At the 50th mile the elevation is about 6,000 ft., and the ascent upward is steady and rapid until it reaches its highest point at the 106th mile, when the height is 15,665 ft.; in the next 30 miles it descends to 12,178 ft. at Oroya, or nearly 120 ft. in the mile, while the ascent from the sea is an average of 150 ft. per mile. Smelting works have been established in places adjacent to the terminus, where ores from the neighboring districts are reduced to a form suitable for conveyance to the coast and exportation. Oroya is likely to become a place of great commercial importance, and already there is unusual business movement and animation there. The Consul says it is to be hoped that the Government of Peru and the Peruvian corporation may soon find it mutually advantageous to extend the line by Tarma and Chanchamayo to the point at which the fluvial navigation begins, for, when once it has direct and easy communication with the Amazonian regions and the Atlantic, Peru will be on the high road to prosperity.—*London Times.*

Third Avenue Bridge, New York City.—In compliance with the United States requirements it is probable that there will be a new bridge built across the Harlem River at the upper end of Third Avenue, which will be 24 ft. above the water-line. The proposed bridge is to be a riveted through drawbridge, 300 ft. long and 86 ft. wide, which, it is said, will be the widest swinging bridge yet constructed. The pivot pier of the bridge is to be an annular wall of masonry supported on an annular wooden caisson foundation, which will probably have to be sunk about 45 ft. below main water. The draw is to be built of open-hearth steel. It is to have two railroad tracks, two roadways, and sidewalks on overhung brackets. The roadways of the draw-span will be paved with asphalt. The deck spans will be paved with granite blocks on the corrugated floor, and the sidewalks will be paved with bluestone flags. The operating machinery will be in a machine house over the roadway. Engines and boilers will be in duplicate. The steam plant will be two 10 × 7 in. double-cylinder oscillating engines, and each is separately coupled to a differential gear in proportion of 19 to 1. Each end of the draw will have four hydraulic cylinders for supporting and locking the ends of the draw. There will be two 60-H.P. boilers designed for a working pressure of 100 lbs. The draw will weigh 1,700 tons, and be supported on 96 wheels 12-in. tread and 2 ft. in diameter. The bridge can be revolved through one-quarter of a circle in a minute and a half. It will be lighted by an incandescent electric light plant installed in the engine house near the center of the bridge.

A Ferry Bridge.—A bridge of somewhat novel type has been erected at Portugalete, on the Spanish coast of the Bay of Biscay. According to *Le Genie Civil* it is the joint invention of M. de Palacio, a Spanish architect, and a French engineer, M. Arnodin. The bridge is for the purpose of spanning a large piece of water between Portugalete and Las Arenas. The idea is to enable large masted vessels to pass unimpeded under the span, and yet to avoid any undesirable gradient. The structure consists of a long trellis girder resting upon iron piers, and further supported by a suspension chain fixed in the ordinary manner. Rails are laid upon the girder, along which runs a frame on friction wheels. From this is slung by wire ropes a ferry car. The motive power may be applied in such way as is thought desirable. In any case, with this description of bridge no roadway or flooring is needed. The span at Portugalete is 530 ft., with a headway of 128 ft. If an ordinary bridge had been built with the roadway at the same elevation, an approach half a mile long with a gradient of 1 to 20 would have been required. A small foot-path on each side of the girder or platform allows of the passage of the workman charged with the duty of inspecting and lubricating the rolling apparatus. The working of the bridge has been commenced successfully, and with 150 per-

sons in the car transit of over 500 ft. is accomplished in one minute. The public appear to highly appreciate the convenience and rapidity of the locomotion. When fully loaded the weight of the car is 40 tons, and it is claimed that the principle could be applied to the conveyance of goods, road vehicles, or even railway trains.

Boring to a Depth of 6,560 ft.—The deepest boring of which we have any knowledge up to the present time is at Parvschowitz, in the district of Ribnik in Western Silicia. The depth attained is 6,568 ft., and the diameter of the hole is only 2.75 in. The work has been temporarily stopped in order to lower especial thermometers, which have been made with great accuracy, into the hole for the purpose of obtaining the temperature at different depths. The boring will then be resumed, and it is hoped that a depth of 8,200 ft. will be reached. The method of operation is that the Hammersmann tubes are used, great lengths of which can be operated at once. The first tube has a diameter of 11.8 in., and is provided at its lower end with a diamond cutting edge which acts as a drill. The pipe is then screwed, as it were, into the ground, and when it has been entered completely a small special mechanism permits the cutting off of the column of *débris* at the base, whence the core which has been formed in the interior of the tube, and which exactly represents the geological formation, is removed. This is then raised to the surface of the ground and the diamond-pointed cutting edge is raised to the surface and a second and longer tube screwed on, having as its outside diameter the inside diameter of the first one, and it is also provided, on its lower extremities, with a new diamond-pointed cutter. This tube is then dropped into the hole, it is stopped by the first boring, and they begin to screw it down as in the case of the first. When the two tubes are thoroughly imbedded in the ground, the first operation is repeated and the core withdrawn, and thus by successively screwing on to the end of the tube one whose external diameter is equal to the internal diameter of the preceding one, the work is carried on. —*Revue Scientifique.*

Test of Rapid-Fire Guns.—Considerable interest is manifested in the coming international test at Sandy Hook of rapid-fire guns. These, it is now said, will be conducted by a Board of Ordnance officers detailed by Brigadier-General D. W. Flagler, the Chief of Ordnance of the United States Army.

The test of 6-pdr. rapid-fire guns will be supplemented, it is announced, by a test of 4.7-in. rapid-fire guns open to the world.

It is learned that 4.7-in. guns will be submitted by Hotchkiss, Armstrong, Canet, Krupp, Maxim-Nordenfeldt, and Schneider et Cie. The Hotchkiss gun is the only American weapon in the lot, and the Hotchkiss gun which is to be tried is the manufacture of the Hotchkiss shops outside of Paris.

The Canet gun is of French make. That which is to be submitted represents the type now in general use aboard the most modern ships of the French Navy. The Krupp 4.7-in. gun will be of the latest type that is employed in the German Navy.

The Maxim-Nordenfeldt gun is of American-English design, Maxim being an American and Nordenfeldt an Englishman. Maxim-Nordenfeldt guns are fabricated exclusively at present in England.

The gun to be submitted by Schneider et Cie is French both in design and in manufacture. The majority of the guns to be tried will be tested on naval carriages. The army test will comprise rapidity of fire, velocity, penetration, ease of manipulation, and accuracy. The Sandy Hook authorities will endeavor to determine which gun is capable of imparting to its projectile the highest velocity on the least chamber pressure, and at the same time admit of great rapidity of fire with the least possible exertion in manipulating the piece.

The London Tower.—A tower, which it is intended shall eclipse that of the Eiffel at Paris by 175 ft., is to be built in the suburbs of London. There will be three platforms to the tower, at intervening altitudes of 150 ft., 500 ft., and 950 ft. respectively. The area of the first will be about 200 ft. square, and it will be covered by a concert hall, shops, restaurants, and side shows of various kinds. There will be like erections on the second platform, but on a lesser scale, and on the third a post-office with telephonic communication will be the leading feature. If the amount of business transacted on the highest stage of the Eiffel Tower be any criterion, the Postmaster General will have no cause to complain of an unremunerative branch, while the patriotism of its patrons will be gratified by the circumstance that this stage is to be 40 ft. higher than the loftiest which the Parisian erection can boast. Crowning all will be an electric lamp of extraordinary illuminating power. The entire tower will weigh about 7,500 tons, and each of its colossal legs will stand on a solid rock of concrete, already in position and imbedded to the depth of 75 ft. This weight is much lighter than that of the Eiffel Tower, but Sir Benjamin Baker, who built the great Forth Bridge, is superintending the work, and may be safely trusted to make the structure perfectly strong and safe. The four legs are already a third of the way up to the first platform. They stand at the corners of a square of 300 ft. base, within which four elevators will work, and will be able, if required, to carry as many as 60,000 persons in a day. The tower will be entirely of steel. The first platform is under contract to be finished by November of this year, but no date has been fixed for the execution of the entire work, though that consummation may possibly be witnessed by the end of 1894.

Railroads in Siam.—The British Consul-General at Bangkok in his last report mentions that much progress was made in the construction of the Bangkok-Korat Railroad during 1892, and the first sod was cut by the King of Siam on March 9. The line is 165 miles in length. It is to be equipped as a first-class line; gauge, 4 ft. 8½ in.; weight of rails, 50 lbs. per yard. There are to be 183 bridges with abutments and piers of brick masonry, and superstructure of steel. They are generally of small size, crossing the numerous canals of the Menam delta, the broadest measuring only 180 ft. The total tonnage of rails and fastenings required is 15,000 tons, and of this 11,558 tons were imported during the year. Rails are being laid at three different parts of the line. The sleepers, of which 30,000 have been delivered during the year, are of an excellent hard wood, found in abundance in the west of Siam. The laborers for the earthworks are chiefly Chinese, and about 40 miles of this work has been completed during the year. The number of Chinese employed is about 2,000. The majority seek the work voluntarily, and are paid by the task. Siamese, both men and women, are employed. The contract time of completing the work is five years, but it is expected that portions of the line will be open for traffic before the end of that time. The meter gauge line from Bangkok to Packnam, at the mouth of the river, a distance of 14 miles, has been completed, and was formally opened on April 11 this year. The capital of the company amounts to $165,000, and of this half has been subscribed by the king. The rails are English and the locomotives and carriages German. This little pioneer line of Siam has started successfully. The Siamese take readily to this form of locomotion, and large receipts are being made from pleasure seekers, who take trips to Packnam to enjoy the novelty of traveling by steam. The projected line across the Malay Peninsula has now been surveyed, and it is expected that the syndicate will soon begin on the Kedah side.

Electrical Power in Switzerland.—The United States Consul in Chemnitz says:

"It used to be urged that Switzerland's water supply, if properly utilized for obtaining electricity, would reduce very considerably her cost of production. Not only has she many streams, but they fall from such heights that even rivers of small volume have great power. 'Millions of horse power are going to waste in these hills,' was a common expression. 'Switzerland had only to make sluices, put in wheels, lay wires, and get for a "song" what other less-favored nations had to buy with enormous consumption of costly coal,' was what even scientists said only a few years ago. The sluices were laid, dams made, wheels hung, and wires put down. What is the result? Every effort that science could suggest, ingenuity devise, or mechanics arrange was made in different cantons of the little republic to gather electricity by, and transmit it from, her rivers and streams. The latest reports show that if Switzerland, or any country with streams and climate like hers, is to win her way into the world's markets and take a place in the front ranks, it must be by some better method than the use of electricity gained and transmitted from rivers and waterfalls.

"The following table, just published in Chemnitz, shows what 50, 300 and 500 H.P. costs in England, Germany, Bohemia and Switzerland per annum:

Country.	50 H.P.	300 H.P.	500 H.P.
England	$24.24	$12.58	$9.88
Germany	29.21	15.52	$13.51
Bohemia	27.50	14.74	12.97
Switzerland	[illegible]	29.61	25.54

"Compared with the above, the cost of the same amounts of H.P. of electricity transmitted 3.1068 miles (5 kilometers) in an air line in Switzerland, according to results published in connection with the foregoing table, is as follows: Fifty H.P., $30.88; 300 H.P., $16.98; 500 H.P., $12.54. But to this must

be added the transmission cost, which will make the total as follows: Fifty H.P., $57.68; 300 H.P., $31.27; 500 H.P., $25.48.

"How, at these rates, is it possible to turn from steam to electricity? How is it possible for a people using so uncertain and expensive a power to compete with England, Bohemia, Belgium, or Germany? It is only by building a big plant, 500 H.P. at the very least, that electricity begins to show any profit that would commend it as a substitute for steam. It is only then that its prices sink to those of the same amount of power yielded by its rival. The 50 and 300 H. P. gained by steam, even in Switzerland, come cheaper than the same amounts of electric power produced and transmitted from the rivers. These facts may be disappointing, but there they are—the results of experiments.

"Just now the experiments being made in Switzerland are of vital interest to us whose mental efforts, if not practical experiments, are bending toward a utilization of the Niagara, Mississippi, Merrimac, and other streams for the purpose of supplying electrical power to the mills andshops of the United States."

A Cheap Condenser for Exhaust Steam.—In a letter to a contributor of the AMERICAN ENGINEER, Mr. F. H. Wenham, of London, describes a method of condensing the exhaust steam from a high-pressure engine, which is new to us, and probably will be to most of our readers. It is capable of a very extended application, and in many cases would be very useful. Mr. Wenham says:

"There was another odd occurrence in relation to my shop engine: Though I had to burn anthracite or smokeless coal, yet the exhaust steam going up the chimney caused particles of iron to descend in the dew from the steam onto linen hung out to dry in a laundry next door. For this I was threatened with an injunction and damages. I therefore had to take immediate steps to get rid of the exhaust steam. Water was scarce and expensive, so I turned the steam into a disused rainwater well as a temporary expedient; this got rid of it for several days, till the ground got dry and hot; then the steam finally escaped up through the five holes in a stone sink in the corner of the building. Above this was a 5-in. wooden spout reaching to the roof; up this the steam was drawn by a strong draft, but I noticed that none came out at the top. It was all condensed, and fell as a shower out of the open bottom of the spout, and drained back into the sink; and as the wood was scarcely warm, I saw that external or surface condensation had nothing to do with the result: it was simply the rush of cold air mixing with the steam that condensed it. I then at once carried the suction pipe of my feed-pump to the bottom of the tank, and so for years fed my boiler with hot distilled water, very little extra being required to make up waste. The consequence was that my boiler was kept free from incrustation. Several engines that I afterward erected were provided with this inexpensive arrangement, using ordinary stoneware pipes to the top of the building, of course leaving the bottom open for the free ingress of air. The arrangement cost but little, and never caused any trouble. About 16 cub. ft. of air will be required to condense 1 cub. ft. of steam.

The Giffard Gun.—About three years ago we noticed a new gun in which the medium of propulsion was liquefied carbolic acid gas. This was the invention of M. Paul Giffard, whose name has long been known in connection with the injector for steam boilers. The gun then introduced into this country was of the original French pattern, but since that time it has been much altered and simplified in detail and construction, the principle, however, remaining the same. The new gun is 3 ft. 9 in. in length with a hexagonal barrel, having a .295 in. bore, and weighing 6 lbs. The liquefied gas is contained at a pressure of 2 tons per square inch in a steel tubular reservoir 9 in. in length, fixed under, and in a line with the barrel of the gun, the combination producing a very handy and well-balanced weapon. In charging the gun a lever which forms the trigger guard is lowered; this opens a chamber for the insertion of a conical bullet, cocks the gun, moves an indicator which shows the charges expended, and places the gun at "safe." When the lever is returned to its normal position the bullet chamber is closed, and the bullet placed in line with the barrel. The safety catch is released by the thumb, and when the trigger is pulled the tumbler strikes a discharging pin. This actuates the valve of the reservoir, which it momentarily opens, causing the omission of a charge of gas. The gas expands in the bullet chamber, and drives the projectile before it through the barrel. It is claimed for this gun that it is practically noiseless and entirely smokeless; has little or no recoil, and does not foul. That it possesses these and other advantages was demonstrated at a series of trials which took place at some improvised shooting-galleries in Queen's Road, Nottingham. In addition to the good qualities already indicated, the gun was shown to possess those of accuracy and penetration. It is being manufactured by the Giffard Gun & Ordnance Company of Copthall House, Copthall Avenue, London.

Coaling Vessels at Sea.—The test of transferring coal from one vessel to another, which was alluded to in our last issue, was conducted by the Navy Department in the following way: It consisted of the transferring of a ton of sand put up in bags of 200 lbs. each from the *Kearsarge* to the *San Francisco*, while the latter was towing the former at the rate of about 1 knot an hour outside Sandy Hook, the ships being 250 ft. apart. On the forward deck of the *Kearsarge* two spars 50 ft. high were erected and firmly lashed to the fore-yard. These were guide-poles for the heavy counterpoise weight. From the weight a wire rope was run up to the top of the poles and passed through a block and run down to the stern deck of the *San Francisco*. On this transmission wire the travelers ran, each carrying a single bag of sand. The only object of the counterpoise was to keep the transmission wire taut. The starting-place was about level with the foretop of the *Kearsarge* and was some 36 ft. higher than the receiving deck of the *San Francisco*, so that the travelers and their load ran down by the force of gravity. A switch at the end dropped them on the deck, whence they were removed by hand. The bags were raised to their starting-place in the car traveling on an oblique stay, which reached to the *Kearsarge's* deck. The test was thoroughly successful. Ten bags were transferred to the *San Francisco* in 20 minutes. The apparatus worked without a hitch. The rate was slow, only three tons an hour, but speed can easily be doubled, if not quadrupled.

AMERICAN AND ENGLISH LOCOMOTIVES.

(*Continued from page* 516.)

SPECIFICATION OF AMERICAN LOCOMOTIVE.

SCHENECTADY LOCOMOTIVE WORKS,
SCHENECTADY, N. Y., January 5, 1893.

SPECIFICATION No. —— of an eight-wheel passenger locomotive engine for New York Central & Hudson River Railroad.

GENERAL DESCRIPTION.

Gauge, 4 ft. 8½ in.; fuel, bituminous coal; cylinders, 19 in. in diameter, 24 in. stroke; drivers, 84 in. in diameter; driving-wheel-base, 8 ft. 6 in.; total wheel-base, 23 ft. 11 in.; weight in working order, on drivers, about 82,200 lbs.; total, about 123,000 lbs.; general design shown by photograph of Engine No. 897, New York Central & Hudson River Railroad.

BOILER.

To be of the best workmanship and material, to be capable of carrying with safety a working pressure of 180 lbs. per square inch, and of sufficient capacity to supply steam economically. All horizontal seams with butt joints quadruple-riveted with welt strips inside and outside. A double-riveted seam uniting waist with fire-box. All plates planed at edges and calked with round-pointed tool. Boiler to have extended front end.

Waist, dome, and outside of fire-box of steel, ½ in. × 9/16 in. thick; throat, ⅝ in. thick; diameter of waist at front end, 58 in.; made wagon top, with 1 dome 30 in. in diameter placed on wagon top.

FIRE-BOX.

Of best quality of fire-box steel, 96 1/16 in. long, 40¼ in. wide; front, 70½ in. deep; back, 58½ in. deep; crown sheet, ⅜ in.; tube sheet, ½ in.; side and back sheets, 5/16 in. thick; water space, 4 in. front, 3 in. sides, 3 in. back. All sheets thoroughly annealed after flanging. Fire-box ring double riveted. Staybolts ⅞ in. and 1 in. in diameter, screwed and riveted to sheets, and placed not over 4 in. from center to center.

Crown sheet supported by crown bars made of two pieces of wrought iron 5 in. wide, ½ in. thick, placed not over 4½ in. apart, reaching across crown and resting on edge of side sheets. Crown bars riveted to crown sheets with ⅞ in. rivets placed not over 4 in. from center to center, each bar having 4 stay-braces to top of boiler or dome.

TUBES.

Of charcoal iron No. 11 W. G., 268 in number, 2 in. in diameter, 12 ft. in length, set with copper ferrules at both

ends, swedged at back end, and beaded both ends. Cleaning-holes at corners of fire-box, and blow-off cock in throat.

GRATE.

Grates, rocking.

STACK.

Smoke-stack, straight; deflecting plate and netting in smoke-box.

FRAMES.

Of best hammered iron; main frame in one section, with braces welded in. Forward section securely bolted and keyed to main frame. Pedestals protected from wear by cast-iron shoes and wedges, and locked together at bottom by bolt through cast-iron thimble. Width of frame, 4 in.

CYLINDERS.

Of close-grained hard charcoal iron. Cast with half saddle attached, the right and left cylinders from the same pattern and interchangeable. Fitted together in a substantial manner and securely bolted and keyed to frame. Valve face and steam-chest seat raised above face of cylinder to allow for wear. Cylinders oiled from Nathan No. 9 double-sight feed lubricator placed in cab, with copper pipe under boiler lagging to steam-chest.

the best charcoal iron and turned to 77 in. diameter to receive tire.

TIRE.

Of steel, 3½ in. thick, both pair flanged 5½ in. wide. Tire held by retaining rings.

AXLES.

Of hammered iron, with journals 8½ in. in diameter, 10½ in. long. Driving-boxes of Ajax metal, with large oil cellars.

SPRINGS.

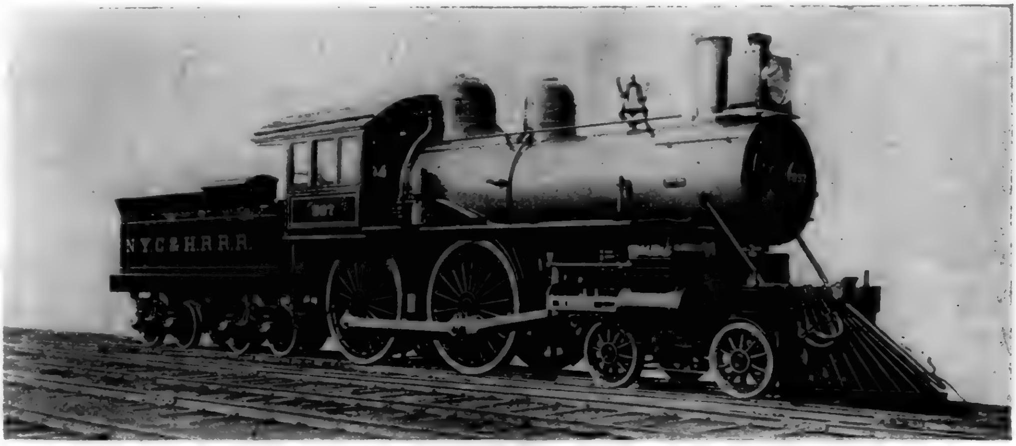
Made of the best cast steel, tempered in oil. Secured to a system of equalizing beams to insure the engine riding in the best possible manner. Springs hung underneath the driving-boxes.

RODS.

Connecting and parallel-rods of the best hammered iron, each forged solid, fitted with all necessary straps, keys, bolts, and Ajax metal brasses. Parallel-rods with solid ends, channeled bodies.

CRANK-PINS.

Of hammered iron.



AMERICAN EXPRESS PASSENGER LOCOMOTIVE, BUILT BY THE SCHENECTADY LOCOMOTIVE WORKS.

THROTTLE.

Balanced valve placed in dome, with wrought-iron dry-pipe and cast-iron steam-pipe connecting to cylinders.

PISTONS.

Made with removable follower, and fitted with approved cast-iron steam packing. Piston-rods of hammered iron.

VALVE MOTION.

Approved shifting-link motion graduated to cut off equally at all points of the stroke. Links, sliding blocks, plates, lifting links, pins and eccentric-rod jaws of the best hammered iron, thoroughly case hardened.

GUIDES.

Of hammered iron, case hardened.

VALVES.

Richardson balanced steam-chest valves

PACKING.

United States metallic packing on piston-rods and valve stems.

CROSS-HEADS.

Of cast steel with brass gibs. Style for 4-bar guide, top guides 4 in. wide.

DRIVING-WHEELS.

Four in number, about 84 in. in diameter. Centers cast of

WATER SUPPLY.

To have two "Monitor" injectors; one No. 10 right side and one No. 9 left side, with well-arranged cocks and valves for convenience in working.

ENGINE TRUCK.

With square wrought-iron frame, cast-iron pedestals, and center-bearing suitable for rigid center, with approved arrangement of equalizing beams and springs.

WHEELS.

Four Krupp steel-tired spoke wheels, tire held by retaining rings 36 in. in diameter.

AXLES.

Of hammered iron, with inside journals 6 in. in diameter and 10 in. long. Springs of best cast steel, tempered in oil.

CAB.

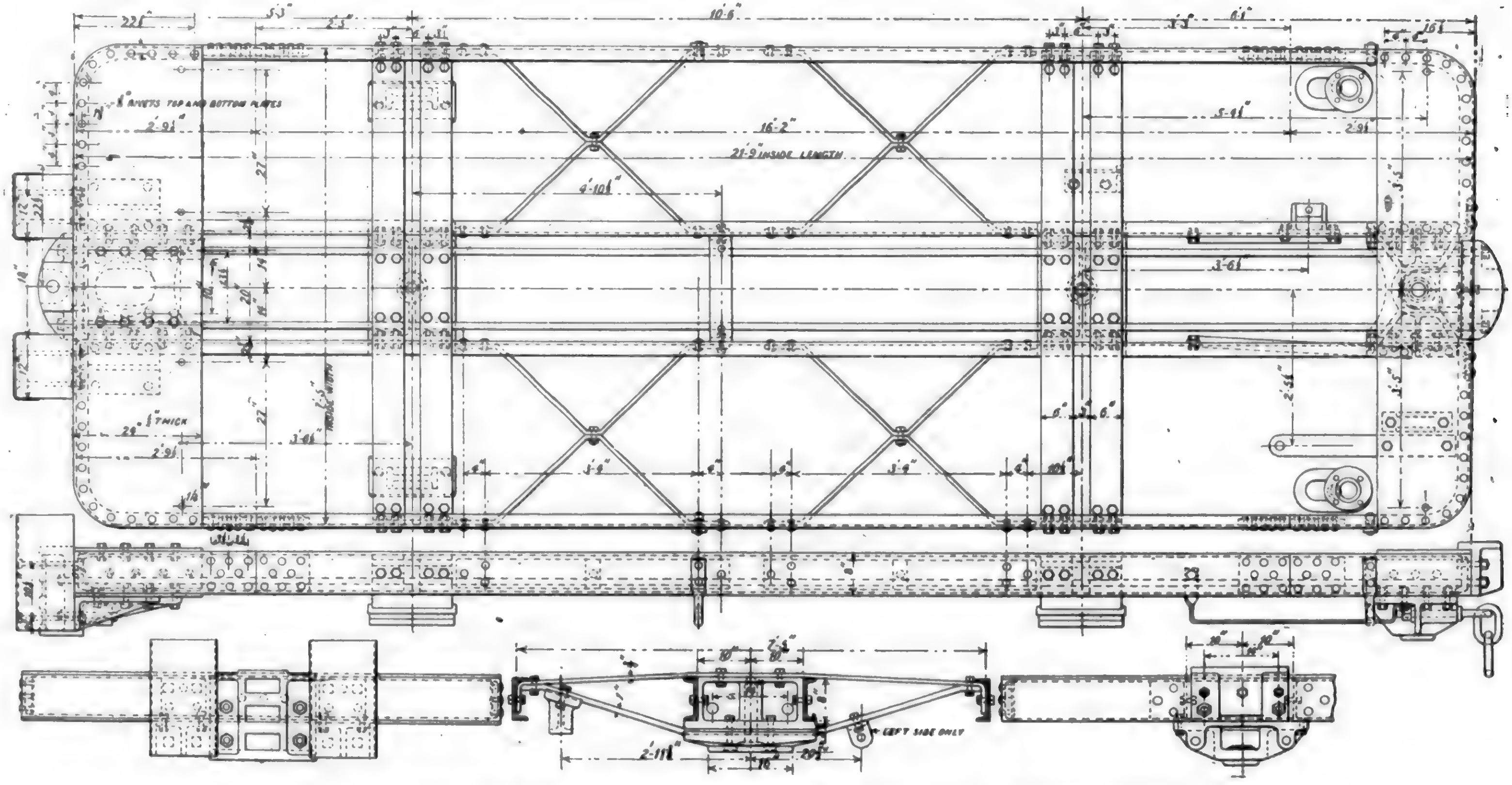
Constructed of seasoned ash, substantially built, and secured by joint bolts and corner plates. Furnished with seats and tool boxes for engineer and fireman.

PILOT.

Of wood, strongly braced, and provided with substantial draw-bar.

FINISH.

Boiler lagged with asbestos cement and jacketed with planished iron; secured by planished iron bands. Dome lagged



IRON TENDER FRAME, BUILT AT THE READING SHOPS OF THE PHILADELPHIA & READING RAILROAD.

with asbestos cement, with sheet-iron casing and cast-iron rings, painted. Cylinders lagged with wood, with sheet-iron casing and cast-iron head covers, painted. Steam-chests cased with sheet iron, with cast-iron covers, painted. Handrail of iron, painted, with columns secured to boiler.

FIXTURES AND FURNITURE.

Engine provided with sand-box, support for headlight, bell, whistle, Utica steam-gauge, gauge cocks, cab lamp, heater, blower, oil cans, torch, also all necessary wrenches, fire tools, hammers, chisels, packing tools, etc. Two jack screws and a pinch-bar. One 23-in. Williams side-illuminated headlight. Principal parts of engine fitted to gauges and templates, and interchangeable. One 8-in. cab gong. All finished removable nuts case hardened. One water-gauge lamp. All threads United States standard. Smoke-box jacketed with sheet iron and planished iron.

SAFETY VALVES.

Two 3-in. Richardson muffled valves set at 183 lbs. and 185 lbs.

TENDER FRAME.

Substantially built of 6½ in. × 4½ in. angle iron, and thoroughly braced. Back end fitted with "Gould" coupler.

TRUCKS.

Two four wheeled side-bearing trucks, made with wrought-iron side bars and wood bolsters.

SPRINGS.

Made of the best cast steel, tempered in oil.

WHEELS.

Krupp steel-tired plate wheels, tire held by retaining rings 36 in. in diameter.

AXLES.

Of hammered iron, with outside journals 4½ in. in diameter and 8 in. long. Brake on front truck only.

TANK.

Of 3,500 galls. capacity, strongly put together with angle-iron corners, and thoroughly braced and stayed, and well secured to tender frame. Tank fitted with water scoop.

PAINTING.

Engine and tender to be well painted and varnished, with the road, number, mark and name put on in handsome style.

PATENTS.

All patent fees not covered by this specification excepted.

BRAKE.

Westinghouse automatic air brake on drivers, tender, and for train, with engineer's air signal. Ross-Meehan driver brake shoes.

HEATING SURFACE.

Tubes, 1,672.1 sq. ft.; fire-box, 147.7 sq. ft.; total, 1,819.8 sq. ft.

GRATE SURFACE.

Twenty-seven and three-tenths square feet.

The specification for the English engine will be published in the January issue.

(TO BE CONTINUED.)

IRON TENDER FRAME, PHILADELPHIA & READING RAILROAD.

Every one who has had to do with railroad rolling stock, especially with that pertaining to the locomotive department, is familiar with the discussions which have arisen from time to time regarding the relative merits of the iron and the wooden tender frames. The advocates of the latter base their arguments upon the fact that, in case of an accident, such as a derailment or collision, when one of the sills of the wooden frame is broken, it is very readily and cheaply replaced without the necessity of tearing the whole frame to pieces. They claim, on the other hand, that with the iron frame, in case of such accidents, it is certain to be bent to a greater or less extent, and that, owing to the weight of the metal of which it is composed, it is necessary to remove the sill or the part bent and take it to the blacksmith shop for heating in order that it may be brought back into alignment. This latter claim is undoubtedly true in regard to many tender frames which have been put under tanks. It is one of those cases where the theoretical calculations in regard to the weight to be carried and the strain to which the parts will be subjected do not at all coincide with the actual requirements of the case. The jarring of the load in running over a rough track, or the pounding which a frame is apt to receive should a wheel leave the rails, is apt to be very much in excess of what was usually allowed in the theoretical calculation of strains, just as we find the truck bolster of freight cars coming down and allowing the car bodies to ride upon the side bearings, although the calculations and tests which have been made of the bolsters would seem to show that an ample factor of safety had been allowed.

A similar experience to this has obtained on the Philadelphia & Reading Railroad with a number of tender frames which they have built. The depth of the channel bars forming the sills has heretofore been 6 in., and this depth has shown itself to be insufficient for the work which is to be performed under the large tanks which are used as tenders for their heavy freight engines. In order to overcome the difficulty of bending and to render the frame stiff against all ordinary and extraordinary shocks short of an actual collision, the tender frame which we show in the accompanying full-page engravings has been designed. The depth of the channel bars forming the sills has been increased to a depth of 8 in., and instead of bolting the corners with angle irons or making a short bend and using an extra piece for an end sill, the outside sills have been rounded out with a radius of 9 in. for the outside of the curve, and the two ends are butted together on the center line of the frame. Here they are held in position by heavy castings, as shown by the engravings. There is one which takes the draw-pin and lays inside of the frame, bolting to the two inside sills, and on the outside there is the heavy buffing casting, so that any buffing strains which may be brought to bear on the frame at this point is carried direct to the inside sills, and has no tendency to cause a bending strain on what practically becomes the end sill of the frame.

In addition to the stiffening which is obtained by these two castings, a plate of ½-in. metal is riveted across the end as shown. The body bolsters are made of iron 6 in. wide, using a thickness of ¾ in. for the extension members and 1 in. thick for the compression.

Another feature of the frame which is well worthy of attention, and from which the designers expect to obtain very good results, is the use of two 1¼-in. bolts which extend through from end to end of the frame, bolting the buffing and draw castings in position. It will thus be seen that any strain which is brought to bear by the sudden pulling out of the engine or the jerking of the train on the draw-bars is carried through from the engine to the train, or *vice versa*, by way of these draw-rods, and there is no strain whatever put upon the general body of the frame with this form of what is practically a continuous draw-bar. Although the frame is braced by diagonal braces made of ¾ × 5½ in. iron, it is evident, from their location and the space which is available for them, that they would not serve to prevent a diagonal distortion of the frame as the result of abnormal strain, and this is one of the troubles which has heretofore been experienced with the iron frame, that if the rivets become loose the frame is apt to become distorted, and with the distortion follows the inevitable weakness. This frame, however, by being so constructed that its general contour is not affected by either buffing or pulling strains, is freed from these inconveniences. It is expected, as we have already said, that it will have a sufficient strength to resist all ordinary strains of derailments and shocks without deformation, and that it will go far toward settling the relative merits of the iron and the wooden frame.

PROTECTING PILES AGAINST THE TEREDO NAVALIS ON THE LOUISVILLE & NASHVILLE RAILROAD.*

By Michael L. Lynch.

In 1880 the Louisville & Nashville Railroad Company acquired control of what is now known as the New Orleans Division of that road, and with this acquired also a large creosoting works, located at West Pascagoula River.

This road crosses a number of bays, bayous, and rivers, all of which are spanned by means of yellow pine creosoted pile trestles, and iron bridges supported by creosoted pile piers. There are 21,407 linear feet of trestle and 6,459 ft. of iron bridges. The most noteworthy structures, so far as the sub-

* Paper read before the American Society of Civil Engineers.

ject of this paper is concerned, are Bay St. Louis and Biloxi Bay trestles, the first of which is about 2 miles long, and consists almost entirely of creosoted yellow pine; that over the second is 6,040 ft. long and consists of 5,850 ft. of creosoted pile trestle. Each of these structures has an iron draw span 190 ft. long. These trestles were built in the years 1878 and 1879, and replaced structures which had been destroyed by the teredo, which in the waters of the Mexican Gulf and its estuaries are extraordinarily destructive on account of the long warm season. An untreated yellow pine pile, 12 or 15 ft. in diameter, would be rendered unsafe for structural purposes in less than six months. In 1871 a serious accident occurred at the Biloxi Bay trestle from this cause, although the piles were only about 10 months old; seven bents went down with a freight train, and it was found that the piles were all eaten off close to the bottom of the water. When first built, the trestle had hardly been completed when it was found that the untreated piles were so badly attacked by the teredo that rebuilding had to be commenced at once. In 1872 resort was had to covering the piles with copper, but the protection was not perfect. For this reason creosote works were built in 1876, at a cost of $60,000. All creosoted structures have been periodically inspected, and the portion below water examined from time to time by divers. It was not, however, until 1886 that it was found the teredo had begun his attack on the creosoted piles. About the same time an inspection of the creosoted piles in the railroad company's wharves at Pensacola, Fla., disclosed a similar condition of affairs, and the question of determining, if possible, on some further means of protecting the creosoted piles against the teredo became a vital one. As a result of investigation and experiment, it was decided to adopt a thin coat of cement mortar or concrete, applied to the outside of the piles from the surface of the mud or sand at the bottom to high water at the top. To accomplish this a shell of wrought iron made of circular form, composed of several sections, each in two segments, and so arranged to be easily separated, was placed around the pile; the shell was clamped together above the water and lowered section by section until it completely surrounded the pile to a short distance below the bottom. A diver placed a pudding of "gumbo clay," enclosed in sacking, between the shell and the pile at the bottom, before the shell was forced down. Where the water was not more than 12 ft. deep, it was pumped out and the mortar or concrete poured in. Where there was more than 12 ft. of water this could not be done, and concrete was passed to the bottom of the shell, through a special galvanized iron pipe, with a funnel or feeder at the top for filling. This was raised as the space below was filled up. The bottom was kept constantly in the concrete. The shell was allowed to remain until the concrete had set, when it was removed and placed on the next pile. Shells made of wood with cast-iron bands were also used, as being cheaper than the wrought iron. This method of treatment was applied to over 4,000 piles, but only such as had been seriously attacked, so as to prevent their total destruction. One important advantage of this method is that there is no disturbance of the piles or superstructure which rests upon them, a matter of special importance where the piles are under large storage sheds or other buildings.

There has been some little trouble experienced from logs or rafts striking the protected piles in rough weather, but the repairs have been small, and the protection, which has now stood seven years, bids fair to continue a number of years longer. Not only did the concrete completely cover the piles, and was itself covered with oysters, barnacles, etc., but the cement had found its way into the teredo holes, filling them even to the heart of the piles and forming within it perfect casts of the teredo. Not a single living teredo was found in the piles when afterward split.

The concrete used consisted of one of cement, two of sand, and three of gravel, with water enough to make it pass easily through the pipe. The cost of its use was found to vary from 80 cents per linear foot measured on the pile, to $1.50 per linear foot, depending upon the length of the protection, the location of the piles, and the conditions of the weather; but as the number of feet protected was only from high watermark to the bottom, it was small compared with the total length of the piles, and much less than it would have cost to replace the old piles with new creosoted ones.

The next protection used was vitrified clay pipe. In 1892 a careful inspection was made of the piles of the Bay St. Louis and Biloxi Bay trestles; of these about one-half was found seriously affected, some were full of small holes, and a very considerable number with large holes. About 15 per cent. had been protected. It was decided at once to proceed with the protection, and also to strengthen the caps and stringers, which were too light for the existing rolling loads. The trestles had been in service 14 years, but were found, with the exception of a few ties, to be in a good state of preservation. It is expected that the life of the new cypress used will be as long as the remaining life of the old creosoted pine, and that, when renewal above the water is required 10 or 12 years hence, a frame trestle can be placed on top of the protected piles.

Instead of using concrete protection for th piles, in this case vitrified clay pipe was used, first for economy, and, secondly, because it was believed to be a more certain protection at the immediate surface of the mud, it having been found that with the concrete protection some of the mud had become mixed with the concrete at the bottom, killing the cohesive power and leaving the piles open for attack by the teredo. In most localities the teredo works near the surface of the water, between high and low tide, and his ravages become less as the bottom is approached. At Biloxi, this is different, due to the fresh water which flows in on top of the salt water, and the teredo thrives better near the bottom. It is quite common to find piles eaten off at the surface of the mud and showing no indication of attack above that point.

In order to allow the sections of pipe to be passed readily over the piles, they were cut off at some distance below the stringers, making it necessary to use a bolster or some other contrivance to support the stringers. The bolster was made to extend the full panel length, and its upper surface keyed to the lower surface of the stringers with cast-iron keys, to make it act with the stringers. This also permits the easy removal of the sticks or the bolster independently of each other.

There has been much trouble with both of these trestles on account of fires caused by sparks dropped from engines. It was therefore determined to box in the floor and cover it with gravel.

The sections of the pipe were fastened together with a composition of pitch and sand, applied hot. This was cooled as each joint was lowered below the surface of the water, and became hard so as to hold the sections firmly together. In this way section after section was added until a solid bearing below the mud surface was reached. Jacks were used to force the pipe down, after which the space between the pile and pipe was filled with sand, which was allowed to settle. After several months the pipes were again filled, to make up for settlement and that which had been washed out by waves, and they were then sealed on top with the hot pitch and sand.

The cost of this protection was 66 cents per foot of pipe for 16-in. pipe, and 71 cents for 18-in. pipe, which figures include freight and every expense. The length used on each pile varies from 2 ft. 6 in. near the shore to 15 ft. on each pile, the piles being 50 to 60 ft. long.

A test pile infested with live teredos in a healthy state was treated in this way, and at the end of 24 hours it was found that the teredos were all dead and turned black. In 48 hours more the bodies of the worms had almost disappeared. At the end of a week the pile was pulled up and split in pieces, and nothing could be found except the holes which the teredos had left. We were therefore fully assured of the utter destruction of the teredo by this method and the sure protection of the pile.

In cutting off about 4,000 piles at both trestles, not one was found to be decayed, although they had been in place 14 years. This is a good record for yellow pine treated with dead oil creosote. All indications would show that they would be good for at least 10 years of service. Untreated yellow pine piles would not last in this climate more than an average of seven years, assuming that the teredos did not eat them up in far less time.

THE HANDLING OF FUEL ON THE FRENCH, ENGLISH AND BELGIAN RAILWAYS.*

By M. Jullian.

HANDLING ACCOMPLISHED BY USING AN INTERMEDIATE DISCHARGE WITH BASKETS OR TUBS LOCATED ON A FUEL PLATFORM, FROM WHICH FUEL IS AFTERWARD TAKEN TO BE DUMPED INTO THE TENDERS.

Handling Accomplished without Mechanical Assistance.—The general arrangements of the yards and tracks are as follows: The fuel platform is built along a track upon which the engines run; its length is usually that of two engines—it is often greater, but very rarely less; as to its breadth, it varies with the amount of fuel which must be held. On that side of the platform opposite the engine track another track is located

* *Revue Générale des Chemins de Fer.*

which is used for the movement and switching of cars to be unloaded.

The platform is of such a height that the workmen can readily take their baskets or tubs which have been filled from the car and dump them into the tender. It is certain that these arrangements would not be the same if they were to do the work with baskets holding from 88 lbs. to 110 lbs., or with lorries or tubs carrying 1,102 lbs. In the first case, the workmen could raise baskets from 16 in. to 20 in. in their arms if it were desirable; in the second, it would be necessary to adopt such arrangements that the tubs or lorries would have to move either on a horizontal surface or on one slightly inclined.

Loading with Baskets.—This method is very extensively used, but has very little interest; the handling which is done with this arrangement is less expensive than that which is done without any platform, and it insures a more rapid loading; nevertheless, it requires two men about three minutes to accomplish the loading of a ton of coal into a tender, provided the baskets are filled in advance, and the men have only to lift them and dump them into the tenders. This system is quite economical whenever the fuel is taken directly from the cars; but when it is necessary to take it from a coal heap, the handling costs quite as much as it would if there were no coaling platform.

It may be interesting to review the expense of handling fuel placed on tenders with companies where the platform system is used.

Eastern Railway Company of France	$.0855 per ton
Orleans Railway Company	.1425 "
Western Railway Company	.135 "
Eastern Railway Company	.1235 "
Belgian State Railway Company	.0722 "
Midland Railway of England	.095 "
Southeastern Railway of England	.133 "

The lowest cost is on the Eastern Railway of France and the State Railway of Belgium. A great portion of the economy attained by the Eastern Railway Company is due to the fact that in handling their fuel they so arrange their service that a large number of engines are never brought to the loading platform at the same time; the result is that it has not been necessary to engage any extra workmen, and that when the regular gang is carefully handled the cost is light and the daily service all that could be desired.

There is another reason for the economy which has been obtained on the Belgian State Railway, of which it is well to say a few words. The handling of fuels on the Belgian State Railway, like many other classes of work on the road, is contracted for once every three years. The same contractor has charge of 19 different classes of work, handling the different kinds of fuel, the kindling wood, unloading sand, loading cinders, cleaning out engines and tenders, operating turn-tables, etc.

The head accountant fixes a price for each class of work, from which, as a basis, the bidders propose a certain discount. Some of these prices are very good, others less so; but the bidders, having different kinds of work to accomplish at the same depot, can utilize the *personnel* of their gangs to the best advantage, and thus sometimes offer a considerable discount for the sake of securing the contract. The contractor who is doing the work at present is giving a discount of 65 per cent, on the following basis prices:

Loading cars of fuel into heaps	$.0475
Loading the same fuel on to tenders	.057
Loading fuel upon cars after mixing	.057
Loading upon tenders with baskets placed upon a car or platform	.095.

This system requires a very careful oversight, and in order that this oversight shall be effectual it is necessary that there should be a large *personnel*; and still there is a certain amount of work which is more or less neglected, such as the cleaning of engines and the cutting up of fagots. On the other side, the contractors cannot do the work so cheaply in any way as by using low-priced help, which generally consists of men who cannot secure employment anywhere else and who require a constant oversight. This does not prevent the depot masters from exercising a keen supervision at all times to see that there is a rigorous execution of the conditions demanded by the head of the department, so that the contractor is obliged to make a discount for what he failed to do in the previous month. It may also be remarked that on the Belgian State Railways there is not a single platform, properly speaking. The fuel is unloaded into the enclosures made of old ties and built along the tracks which are used for the movement of engines; when these enclosures are once filled up to the top of the ties they serve as a platform for the baskets which are loaded upon cars, and when these are lacking the fuel is taken from the pile itself.

Loading with Tubs.—Almost every English company has adopted the method of loading with tubs or lorries at their coaling stations where there is a considerable amount of coal delivered to the engines. In a general way they use the coal just as it comes from the mines; but all the fuel which is delivered to locomotives is first hauled away in cars, and contracts are made with collieries for regular shipments; but at some stations which are a long distance from the colliery centers storage heaps are built up, and the piles from which a supply has been drawn are immediately replenished. The plants for handling the fuels have, therefore, been built with a view of unloading the fuel from the cars directly into the tender. The principal arrangements adopted, which we will describe, do not differ from one another except in unimportant details.

The Secondary Depots of the London & Northwestern Railway on the Bletchley-Willesden Line.—The fuel yard is located under a shed which is traversed by two lines of tracks intended for the movement of cars and for the storage of engines or cars. This last track is on the level with the depot tracks; the other is placed near the platform and is raised 2 ft. 9.5 in. The platform is located on one side and has a breadth of 10 ft. 5 in. with a length of about 82 ft.; it is above the level of the tracks of the depot by 9 ft. 2 in., and its floor is covered with a cement and cast-iron plates carefully joined together; there are no tracks above it for lorries. The loading track for engines is outside of the shed, and is naturally placed along the wall of the platform; this wall has an opening 5 ft. 10.9 in. wide and 9 ft. 10 in. high to allow a drawbridge to drop through, which is used for the unloading of the lorries. The cars that are to be unloaded are run in upon the elevated track by an engine; they are there stopped upon a scale by which their exact contents are determined; then they are pushed on so as to bring as many as possible next to the platform; the lorries are run up next the cars and filled with a shovel and then run down over the side platform until they reach the engines. Three men are generally sufficient to do the work at these yards: two fill the lorries and a third moves them as it may be necessary.

When an engine is run up it is stopped so that it is in a proper position for taking water from the crane, and in this position the tender is opposite the drawbridge; the man who pushes the lorries about drops the drawbridge and rolls the lorries out to a bumper upon this bridge, and then by means of a bolt controlled from behind he opens the door located at the side of the lorry; the drawbridge does not swing, and there is nothing that can be moved except the lorry. Each yard usually has from 15 to 20 lorries, each containing half a ton of coal, they being of the following dimensions: Length, 3 ft. 3 in.; width, 2 ft. 9 in.; height, 2 ft. 9 in. The lorries are made of iron.

It requires about a minute or more to fill a lorry, but it can be emptied into the tender very quickly. At Bletchley an engine holding five lorry loads, or 2½ tons, can be loaded in about two minutes, or before the engine has finished taking water; it is hardly necessary to say that in order to obtain this result the lorries must be loaded before the engine arrives. The price generally paid is $.05 for loading a ton of coal on the tender, and the workmen make about $.72 per day. When the cars are emptied they are hauled away and replaced by others with full loads. At small stations the shed is covered by the water-tank, as shown in fig. 2. In the large depots the arrangements are the same; at Manchester, for instance, the only difference consists in the length of the platform, which will hold four cars, and in the roofing of the shed, which is simply a double roof, and also contains two unloading bridges, as shown in figs. 4 and 5.

At Rugby the arrangements are the same as at Manchester; but a supplementary shed has been added which serves for loading the station switching engines, or those small machines which run to and fro and carry but about ¼ ton of coal, with baskets; this is shown in the plan of figs. 4 and 5.

At Rugby, where about 130 tons are loaded each day, the work has not yet been put upon a piece-work basis; they are investigating the matter so as to put the price for loading on the proper basis in accordance with the number of baskets handled. We see that these arrangements have the advantage of loading very rapidly and at a low cost; it is true that they have done away with the intermediate operation of unloading into heaps. As for the oversight, the only thing that is necessary to look after is the total amount received and distributed each day; as to the amount given to each engine, they trust to the skill of the workmen, who can easily estimate the amount contained in a lorry. This oversight is evidently insufficient, but it is satisfactory, because the premiums for coal savings given to the engineers are so small that no one has any particular interest in making fraudulent entries as to the amount of coal delivered.

Caledonian North British & Midland Railway.—In the arrangements which we have just examined the cars for unloading are located a little below the level of the platform, so that the filling of the lorries is done slowly and with considerable fatigue, especially when the fuel has been emptied so that the men are working close to the floor of the car. The Caledonian, North British and Midland companies have adopted another arrangement by which the cars to be unloaded stand upon tracks whose level is somewhat above that of the tender which is to be filled. In some cases this arrangement has been obtained without any very great expense, as at St. Rollox, where the station tracks are on two quite different levels; in other cases it has been necessary to build inclined planes from one portion of the yard to the other. St. Rollox depot, on the Caledonian Railway, which is located in the suburbs of Glasgow, figs. 6–10, is only used for freight traffic, and as it distributes but about 90 tons of coal a day, it has no storage heaps. At a distance a single bay 4 ft. 7 in. wide is left open for dropping the drawbridge, which is of a special arrangement, as shown in fig. 10.

The movable portion of this bridge is itself made of two parts: one, which is lowered at the same time as the bridge, and the other, which remains fixed and horizontal; the latter is composed of a strong frame of angle iron, and is fastened to the first by a hinge parallel with that of the drawbridge itself. This frame rests normally upon the bridge; but if it is desired to load from its end, the lorry is pushed out there. It then tilts down and takes an inclination limited by two lugs fastened to the drawbridge.

When an engine is run up for loading, a workman takes a lorry, pushes it out upon the drawbridge until the wheels come up against the semicircular bumper which is on the outer portion, while the other wheel stands near the front edge of the angle-iron frame. The weight of the lorry then facilitates the swinging of the crane, and it is enough to turn the bolt

Fig. 2. SECTION ON CD

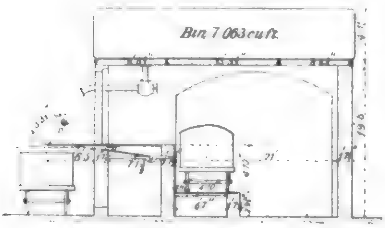


Fig 3. Plan

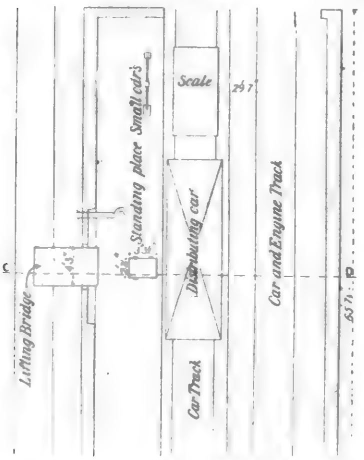


Fig. 4–5. MANCHESTER AND RUGBY YARD

Fig. 4. SECTION ON CD

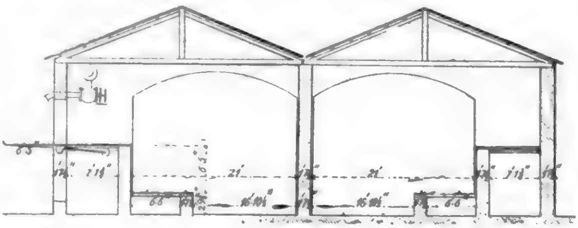
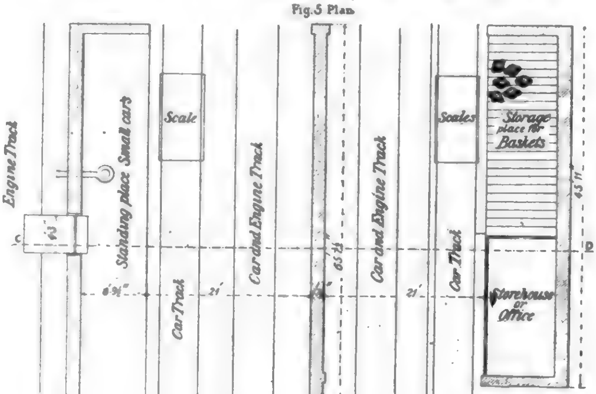


Fig. 5 Plan

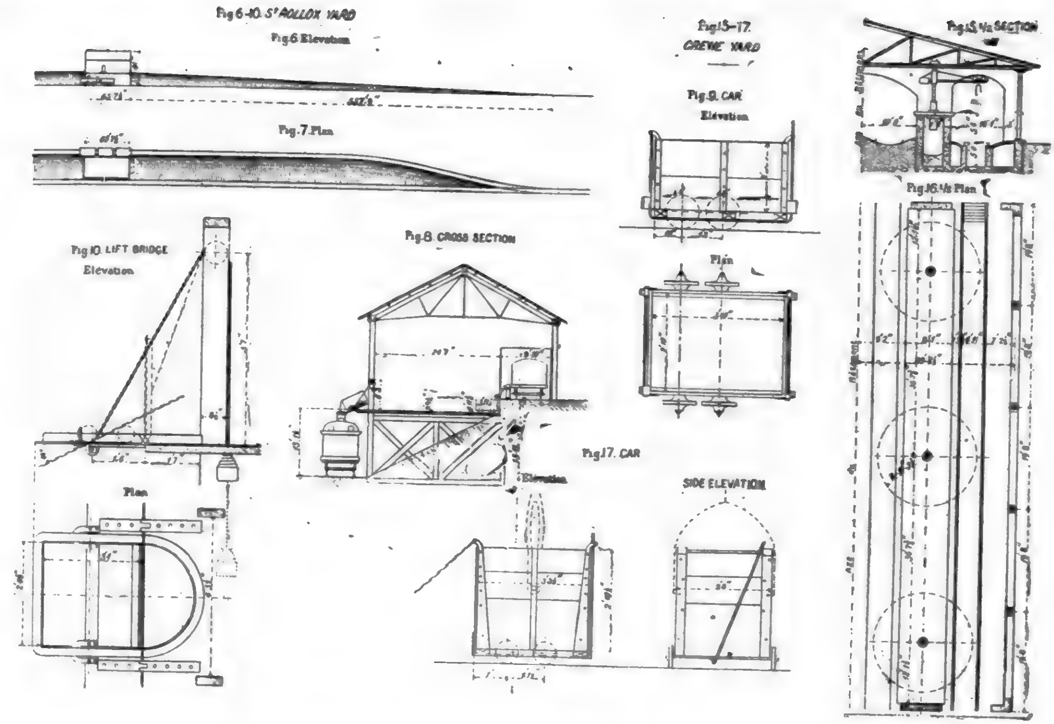


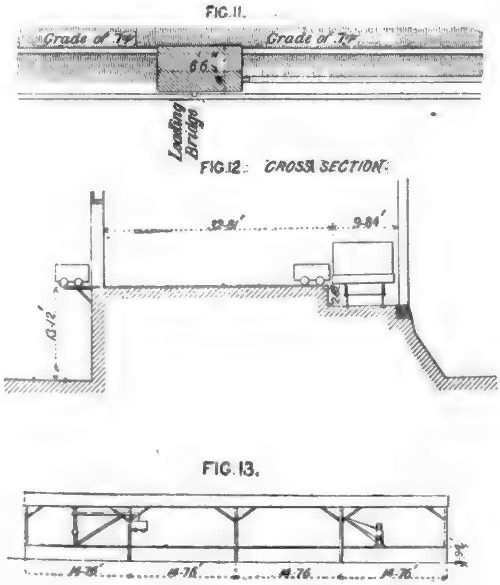
METHODS OF HANDLING FUEL ON THE FRENCH, ENGLISH, AND BELGIAN RAILWAYS.

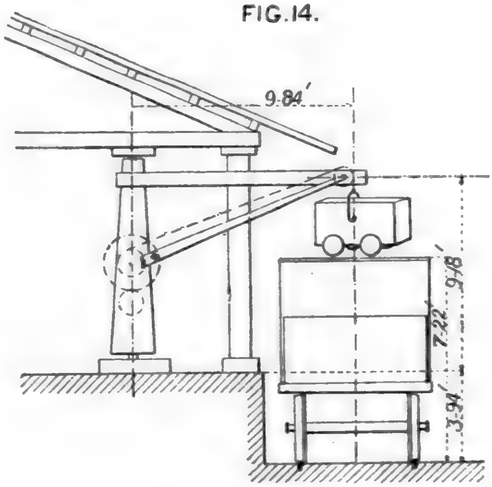
of 656 ft. from the station the yard is separated into two parts at different levels, and the depot itself is built on a platform on a triangular lot, with the low portion of the yard in front and the high portion at the back. Advantage has been taken of this arrangement to locate the coaling place. It is covered just as it is on the London & Northwestern, and occupies a strip of ground 39 ft. × 58 ft. This is clearly shown by figs. 6 and 7, and, thanks to the contour of the ground, it has been possible to locate the floor of this coaling station about 16 ft. 5 in. above the level of the lower tracks, and to switch in the cars to be unloaded upon a track passing through the coaling shed and located at almost the same height above the level of the track where engines are to stand while being coaled. The floor of the shed is made of cast iron plates and old boiler sheets; it is 2 ft. 9 in. below the level of the car track, and consequently the lorries can be filled very rapidly and without very great exertion by means of a small shute. These cars, fig. 9, are 20 in number, and hold ½ ton each; they are made of wood, with iron angle bars for corners, and are of the dimensions shown on the engraving. When they are once filled they are run into the shed to await the arrival of an engine standing on the loading side. The shed is closed by a partition, and which holds the panel located on the front side to operate the lorry and dump its contents into the tender.

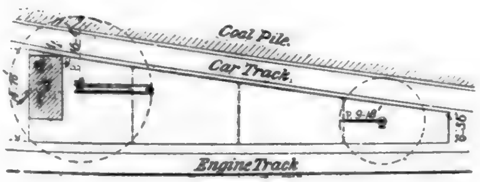
Three cars of coal can be run into the shed at once and unloaded at the same time. Seven men do the work at St. Rollox, three by day and four by night; they are not working by piece-work, but each earns $.83 per day, so that the cost of handling a ton is about $.063.

The work is very rapid, and a tender can be loaded with about two tons of coal in three minutes by working in the following manner: three cars are pushed in on the yard track; as soon as an engine arrives, three shovelers each take an empty lorry and run it up in front of a car, and climbing upon the latter, fill the lorry. The fourth shoveler waits until a lorry is filled, and then shoves it across to the tender. He then shoves another lorry to the first shoveler, and this fourth lorry is usually filled before the other three have been unloaded into the tender. There is no loss of time. If the lorries are filled in advance, it takes about two minutes to unload them. The rapidity of the operation is due to the automatic tilting of the lorry when it reaches the end of the draw. The cars to be unloaded are shoved under the shed three times a day; before this, however, they are run over scales in order to determine









HANDLING OF FUEL ON THE FRENCH, ENGLISH, AND BELGIAN RAILWAYS.

the amount of coal which they contain. As on the London & Northwestern, and for the same reason, a supervision is extended only over the quantities received.

The stations at Motherwell and Palmady have yards similarly equipped; but the natural arrangements of the tracks not being as at St. Rollox, they have built inside tracks for the cars on an inclined plane, as shown by figs. 11 and 12 of the Dundee depot.

The arrangements of the Dundee depot are similar to those which we have already described, as the engravings show. We see in this depot that there are two loading points in order to facilitate operations, but in Dundee there are also two kinds of lorries; one, of which there are 15 in number, holds 500 lbs., and the other, also 15 in number, holds 1,000 lbs. The first is rarely used for road engines; they are only used for switching engines, which are usually run in for coaling at the draw, which is at the end of the blind track. The entrance grade, by which the cars run into the yard, has an inclination of 1.4 per cent. and a length of about 722 ft. It is interesting to note the cost of handling fuel at this yard because it is lower than that at similar depots. The daily delivery is about 130 tons, and the work is done by eight men, four by day and four by night, who earn $.71 per day. As there is no unloading into a heap, the handling of a ton of coal delivered to the tender costs about $.0437.

Handling Coal with Cranes.—In yards where this arrangement has been adopted it is not necessary to elevate the tracks for running in the coal cars. The arrangements are very simple, and consist in separating the track for the unloading of cars from the loading track of engines by a platform upon which a movable crane is located, which swings about a vertical axis, and whose boom is long enough to swing the lorries or tubs from the car to the tender. This crane may be movable either by hand, by a windlass or capstan, or by any other mechanical means, such as steam or hydraulics.

In the installations which we are about to describe, some of the cranes are moved by hand, and in one instance they are moved by hydraulic pressure.

The Carlisle Depot of Caledonian Railway.—The crane has a capacity of about 1,875 lbs.; it is located at the center of the platform, and its boom has a length equal to the distance from the vertical axis of the crane to the center of the entrance track. The work is done with tubs of 1,000 lbs. capacity and not with lorries—that is to say, the movement of the coal is made with the crane; generally the tub is placed in the car to be filled. Usually when they begin unloading the car the tub is placed on the platform close at hand.

At Carlisle 90 to 100 tons of coal are delivered to the engine daily. The work is done in the following manner: When there is no engine there to be coaled the shovelers fill as large a number of tubs as possible, which they stand along the platform. When an engine comes up, one of them devotes his whole attention to hooking on the tubs and swinging the crane, while the others stand by the windlass; but in spite of the rapidity with which they move it is very seldom that they can lift and empty a tub into a tender in less than a minute.

At Carlisle, where the energies of the men are very well utilized, thanks to the general arrangement, eight shovelers are employed, who earn $.76 per day, so that the cost of handling coal is about $.061 to $.0665 for a ton loaded into the tender.

Burntisland Depot on the North British Railway.—The yard at this depot has a slightly different arrangement on account of the preparations which have been made for storing coal in a heap, and that it has been the aim of the designer to use the crane to carry the tubs filled with coal from this pile to the tender as far as possible.

The platform is trapezoidal in form, as shown in fig. 13, and has two cranes; one has a swing of 9 ft. 2 in., and is only used for swinging tubs loaded in the car on to the tender; the other has a boom of 16 ft. 5 in., and is principally used for carrying tubs which are loaded at the coal pile.

The work which is done at Burntisland is very variable, for the depot is used for the handling of coal trains intended to be loaded into boats for transportation. These trains, which are not scheduled on the time-table, are run as extras; so that while some days the yard may deliver only 80 tons of coal, it frequently rises to 140 or 150 tons. This is the reason why they have been obliged to provide a coal heap. The gang is necessarily made up according to the necessities of the case as they arise, and sometimes are not composed of the same men two days consecutively. The work is very regularly done, and these are the only reports which we have been able to gather in regard to the expense which is necessary for carrying on the work and thus relate to all that is done—that is, dumping on to the heap and loading into tenders; and again, these reports, are not very certain, as the shovelers are often at work at other things. There is no doubt, however, but that, according to these reports, the different manipulations of a ton of coal here cost a little over $.076. At Peterborough depot, on the Great Northern, they also have a fixed crane located upon a platform for loading the tenders, as shown in fig. 14. The yard distributes from 120 to 140 tons of coal, and seven men are employed during the day and eight at night. The work is done by contract, and costs $.076 per ton loaded from the car into the tender; at this price the shovelers earn at an average $.76 per day. In winter a storage heap is built up, but this work is done by outside help, and is not included in the contract price.

The Crewe Depot of the London & Northwestern Railway.—(Figs. 15–17.) The depot at Crewe is one of the most important stations in England, if not the most important; it provides for 180 engines, of which 150 at least are in service every day, and about 300 tons of coal are distributed to these daily. In actual service there are very few engines coming in at night—that is to say, between 10 o'clock in the morning and 10 in the evening about 130 are coaled, leaving only 20 on the average for the night. At some hours of the day there are as many as 15 coming in in 10 minutes. It has, therefore, been necessary to adopt such arrangements as would permit the most rapid loading of the tenders, all other conditions being set aside.

The yard is located in a rectangular space, figs. 15–17, having a length of 98 ft. and a breadth of 61 ft. Four tracks run along its entire length; two in the center occupy a space of 20 ft. and one on each side occupy each a strip of land 11 ft. 6 in. wide. On each side, in the space which separates the tracks from the center of the side tracks, a platform has been built having a width of 7 ft. 6 in. and a height of 5 ft. 4 in. above the tracks, and occupying the whole length of this space. On each of these platforms three cranes, wi h booms 9 ft. 10 in. long, are located, whose lifting movement is accomplished by hydraulic pressure; they are easily swung by hand. The engines run in on the side tracks and the cars on the center tracks.

Although the tubs are always carried by the crane, they are provided with little wheels to facilitate the movement of adjusting them near the cars or of moving them about the platform. Their capacity is 1,000 lbs. The work is done entirely with hand cranes. The lorries are set into the car to be unloaded or run up alongside of it, as the case may be, and filled or shoved over the platform or lifted by the crane on to the tender. To expedite this work, the stirrup which lifts the tub is fastened to a small traveling trolley upon the horizontal arm of the crane. The cars to be unloaded first are run over a scale before coming into the yard, and also a second time on leaving it after they have been emptied. They thus exercise a supervision over the total quantity of coal received and distributed daily. In a general way all the fuel delivered to the engine is taken from the car direct; nevertheless, in order to provide for emergencies a coal heap is constructed, and it usually happens that coal is distributed from this heap about twice a year. As these heaps are usually located some distance from the engines, and as loading engines with the fuel which they contain is a difficult and slow operation, a preference is given for running the cars direct into the yard and unloading them as we have described. The unloading on to the heap and the taking of the coal from the heap for the tender is always done by hand either with basket or wheelbarrow.

Before the construction of the coaling station as it is now, the average delivery was about 250 tons a day, and the work was done by 20 men, who earned $.82 per day; but the engineers complained a great deal of the time which they were obliged to lose standing at the coaling station.

The average cost of a ton of coal loaded on to the tender is about $.07. There are 40 tubs of 1,000 lbs. capacity each in the station for distributing 300 tons of coal daily, and only 15 men are employed, who are paid by the piece; they are paid $.0475 per ton loaded on the tender; but there is an additional payment of $.013 per ton for filling the tubs. The average cost of a ton of coal loaded on the tender is about $.066.

The plant, therefore, shows no appreciable saving in the handling of the fuel, but it has the great advantage of only detaining an engine on the loading track for about three minutes. In fact, with this system they are always prepared to load two engines, and, if necessary, four engines at the same time, and the loading of a ton of coal will require 50 seconds if the lorries are filled in advance, and one minute and 15 seconds if it is necessary to fill them, provided that they use two tubs at each crane.

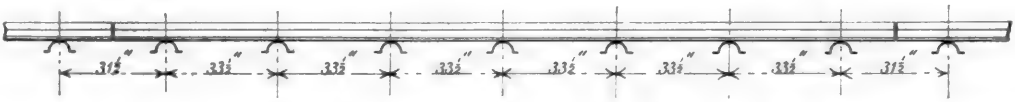
Mr. Webb has not gone to any very great expense in setting up this plant; for a long time he has had hydraulic machines, which furnish the station with the necessary power for its old elevators, cranes, and hydraulic capstans; so that it was only necessary to run his pipes, without changing the capacity of his accumulators in any respect; for as the construction of the cranes is light, a very small amount of water operates them.

METALLIC TIES ON THE GRAND CENTRAL RAILWAY OF BELGIUM.

THE accompanying engraving shows two types of metallic ties—namely, the Caramin and Thy-le-Château, which have been used on the lines of the Grand Central Railway of Belgium. The engravings, with the figuring which is upon them, give such a clear idea of the general construction of the tie that it will not be necessary to enter into a long explanation.

As we see, the management of the Grand Central Railway has tested two types—namely, a type without wooden filling pieces and a type with such pieces. All told, they have laid 11,624 ties on a length of line 6.2 miles long. They were laid in the years 1886, 1887 and 1888. The ballast was composed of broken stones, cinders, and river gravel. The rails, which are made of Bessemer steel and which have a length of 19 ft. 8 in., weigh 83.8 lbs. to the yard; they rest upon seven ties, the spacing of which is in conformity with the outlined sketch, fig. 1, and so arranged as to give a suspension joint.

The ties are 8 ft. 6.3 in. long; weigh, in the old model, 131 lbs., while in the new and strengthened model they weigh 133.6 lbs. each. They are made of iron as well as are also the rivets and the clamp bolts; the tie plates and bolts being made of steel. The heaviest engines which are run over this line weigh 52.3 tons in working order; they have four pairs of wheels coupled, and their rigid wheel-base is 14 ft. 1 in. The maximum speed which is authorized by the government is that of 37.3 miles per hour for passenger trains, 28 miles for mixed trains and 15.5 miles for freight trains. Smith's vacuum brake is used on the passenger trains and the screw brake operated by hand on freight trains. Up to the present time the management of the Grand Central Railway is very well satisfied with the results of these metallic ties when regarded both from the standpoint of stability of the track as well as from that of maintenance, which, according to the reports of the department of roadway and buildings, is more economical than that for those portions of the track which are laid with ordinary wooden ties. The following are some of the official figures:



The expense of maintenance per mile for main line of tracks, as well as for sidings laid with non-injected oak ties, was, on the Grand Central Railway of Belgium, $95,355. This amount is the average of the cost for the years running from 1881–90 inclusive. The expense of maintenance per mile of track with metallic ties was only $11.87. This figure is the average of expense for the years 1886–90 inclusive. No defects have yet been reported in regard to these metallic ties or their fastenings. The track, which is laid upon wooden blocks, is still, according to the reports which the Chief Engineer of the Grand Central Railway of Belgium has made, in far better condition than that of the ties which do not have these blocks.

THE METALLIC TIES.

In the course of a recent discussion of the Railway Budget at the Belgian Parliament, different speakers asked the Government for new tests of metallic ties in order that it might come to the assistance of the metallurgical industry. The Minister of Railways, Mr. Vandenfeereboom, replied to them in a categorical way that the results obtained in the last tests made on a great scale with 75,000 ties by the management of the State railways, and which cost $171,000, had been so unfavorable that they did not think it advisable to go to further expense by increasing the losses which had been thus incurred, and which were very much to be regretted; under such conditions he could not favor new orders for the State railways.

The advocates of a continuation of the tests of metallic ties recognize that while the systems which had been experimented with on the Belgian State railways—namely, the Post and Braet and Bernard ties, had not fulfilled the conditions which had been desired, and had not furnished a good track with metallic superstructure, and while the results had been disastrous, they still thought that the Department of State Railways should make a further test of other types of ties that were constructed in a more rational manner. But the minister remained unmoved in his negative decision. The advocates of renewed tests were somewhat piqued by the fact that the management of the large systems of German railways still continued to give important orders for the delivery of a considerable quantity of metallic ties. What, then, is the reason for this difference in the position taken by the two systems of roads? We think that it will not be without interest to examine into the question.

In the first place, it should be noted that the question of metallic ties was the subject of an animated discussion at a recent session of the Railway Congress held at St. Petersburg, when the report of Mr. Kowalski, Chief Engineer of the Bone-Guelma Railway, was presented, and that in this session, at which nearly 400 members agreed, the following conclusion was reached: "The use of metallic ties will permit of a saving of expense of maintenance when they fulfil the conditions for rational use—in other words, if their form has been so designed and their weight settled by paying careful attention to, first, the conditions of the traffic—that is to say, the speed and weight of the ties; second, to the conditions of the structure of the track and the nature of the subsoil; and third, to the kind of ballast used," etc.

The engineers of the Belgian State Railway have made some reservations from this formula: "By only using metallic ties on lines where the traffic was comparatively light and run over by trains at a low speed." Almost all of the opponents of metallic ties at the St. Petersburg Congress argued from the standpoint of the unfavorable results of the last tests which were made by the Belgian State Railways. It is for this reason that we would consider it interesting to examine into the causes of this want of success from a technical standpoint.

The Bernard ties, which were made of rolled iron and riveted, and which, to the number of 8,000, were removed at the end of a few months on account of a wear in the riveted joints—a wear which was rapidly on the increase with the number and speed of the trains.

The hollow ties of the Post and Braet outlines showed themselves defective in service, as follows:

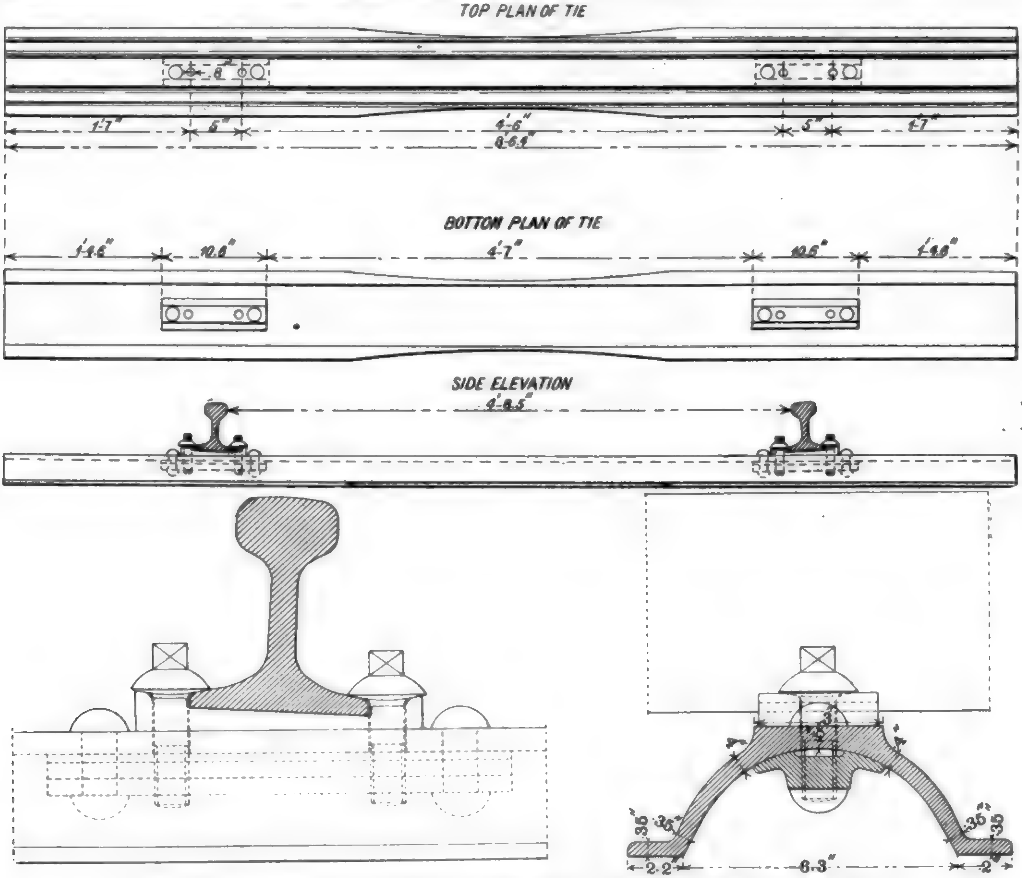
A. The rectangular holes for the fastenings produced cracks and fractures as much as 1.2 in. in length. These fractures, which were discovered in a large number (18 per cent. for the Post and 75 per cent. for the Braet ties) on the heavy traffic line between Brussels and Antwerp in five years of service caused a large number of the ties in question to be removed from service.

In France the same results were obtained with the Post tie, but on a smaller scale. These cracks at the holes, which were foreseen in the Belgium ties, should be imputed to a double cause wherein, contrary to the advice of the department, the steel used was not *very mild*, and because the holes for the fastenings were not punched under the conditions that ought to have been observed. The purchasing agent permitted the holes to be punched instead of drilled on the express condition that the work should be equally good. This opinion is corroborated and shared furthermore by several road masters who have laid Heindel ties on the North Austrian Railway, and who have had no trouble with cracking in the nine years they have been in service. We may add, too, that the method of fastening for the Heindel tie appears to be of a better design than that which was used in the Post and Braet ties by the State Railway of Belgium.

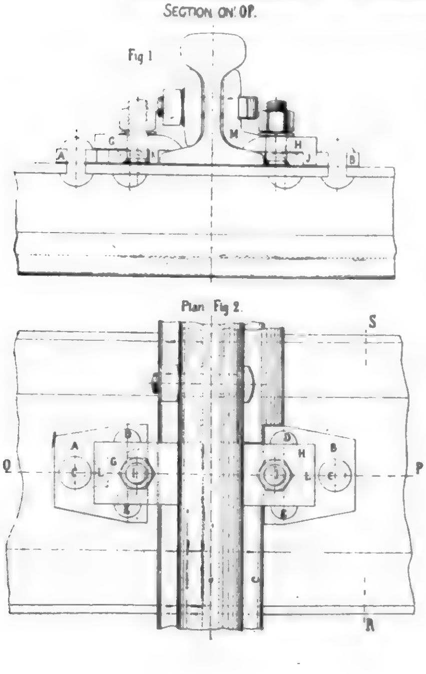
It may not be out of place, however, to say that Mr. Braet had designed a special method of fastening for his tie, but that it was not used on those which were laid on the Belgian State Railway. It is shown in the accompanying drawing.

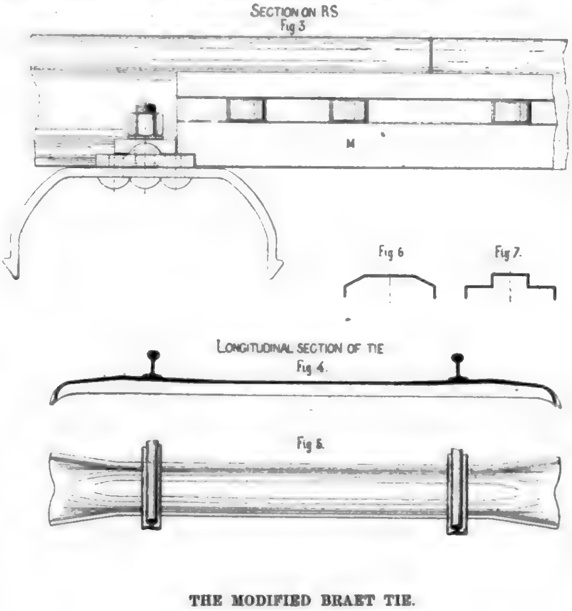
We have no doubt but that if the holes had been drilled and they had not been allowed to exceed a certain size for the ties, the cracks with which they have been troubled would not have appeared. The first fault, then, which can be found with these ties, is one which can be extended to metallic ties in general.

B. In consequence of the alternating up-and-down movement of the hollow tie, it causes a hammering out of the ballast which is transformed into a powder and later into mud by the rain. Each time that the tie rises it sucks in this mud and the ballast loaded with it, forming a kind of macadam which finally forms a hard and compact core necessitating the removal of the ballast from beneath the support. This is the first period of maintenance which is universally recognized as expensive. Under the action of the passage of trains the ties were subjected to a scraping which caused changes both in the longitudinal and transverse directions. These disturbances,



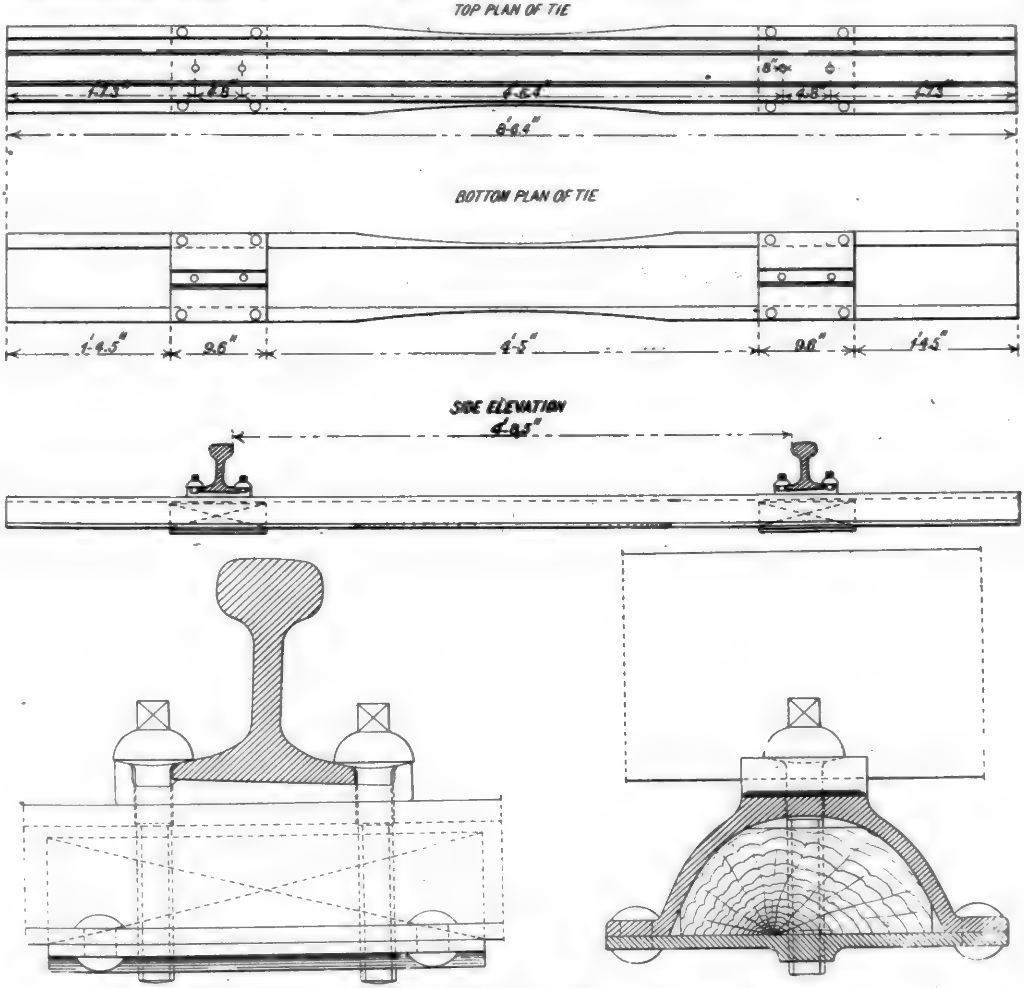
THE THY-LE-CHATEAU TIE WITHOUT FILLING, GRAND CENTRAL RAILWAY OF BELGIUM.





THE MODIFIED BRAET TIE.

which exist for all types of hollow ties and which have been pointed out among others by Mr. Schubert in 1892 at the meeting of the Verein fur Eisenbahnkunde, at Berlin, increase, as it is readily understood, very rapidly and very notably with the speed of the trains. While for a maximum speed of from 47 to 50 miles per hour changes in level are small, and while these small movements exert hardly any influence upon the ordinary track, it has been shown from experiments which have been made at speeds of about 56 miles an hour that they become quite dangerous and may even cause derailments in consequence of the hammer blows and depressing effect of the rolling stock upon a track which has been thus deformed, and it is therefore absolutely necessary in order to bring the track up



THE THY-LE-CHATEAU TIE WITH FILLING, GRAND CENTRAL RAILWAY OF BELGIUM.

to good alignment to demolish the hard cores of ballast which are formed inside the ties. Then the period of expensive maintenance immediately begins. It is thus easily explained why the expense of maintenance of metallic ties on the Belgian State railways was very materially above that of the maintenance of wooden ties, while, especially on the Northern Railway of Austria, there was a saving of 25 per cent. after nine years of service in favor of the metallic tie, as has been stated. Finally, it does not appear to be desirable that the hollow form of tie should be used. In other words, it is well to avoid the use of such ties as permit of the formation of a compact core beneath them, unless they can be easily removed and give great lateral strength. This opinion was also thoroughly brought out in the last discussions of the Verein fur Eisenbahnkunde of Berlin.

According to a report made by Mr. Flamache, Chief Engineer of the Roadway for the Belgian State Railway, for discussion at the St. Petersburg Congress regarding the question of metallic ties, there are some essential conditions to be fulfilled by the metallic tie of the future for lines which are to be traversed by high speed trains:

"1. *They should not require any tamping into the hollow space*—that is to say, they ought to be able to be moved longitudinally and transversely just as a wooden tie is, which has a flat bottom. It is even objectionable to give it any curvature, bendings, or variations of section, or to provide it with bosses or have projecting rivet heads. *Its shape should be perfectly prismatic.*

"2. It should weigh from 165 to 176 lbs. and be made of steel in order to have a strength of from 54,000 to 58,000 foot pounds. Iron is not strong enough. The U form right side up or inverted is not adapted to resist bending stresses, and ought to be excluded. *The outline should be symmetrical* above and below the neutral axis.

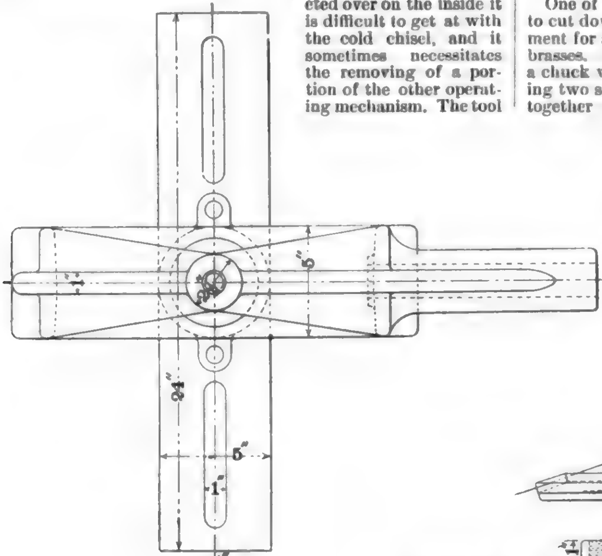
"3. The strength should be obtained with a full outline—that is to say, the sheering strength of the riveted joints should be excluded.

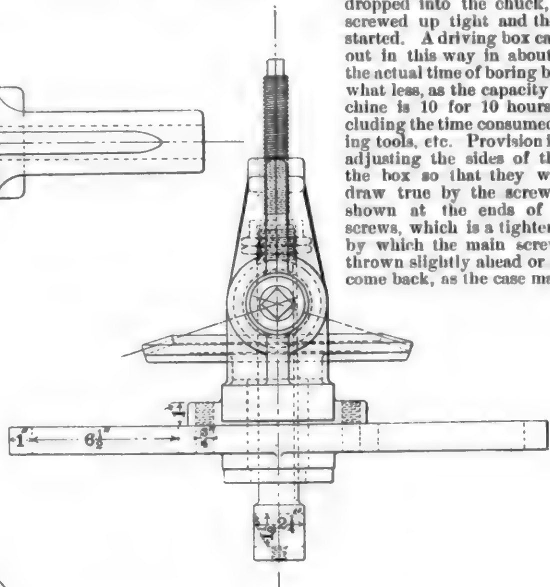
"4. The fastenings should not require rectangular punched holes, but all holes should be drilled, and round."

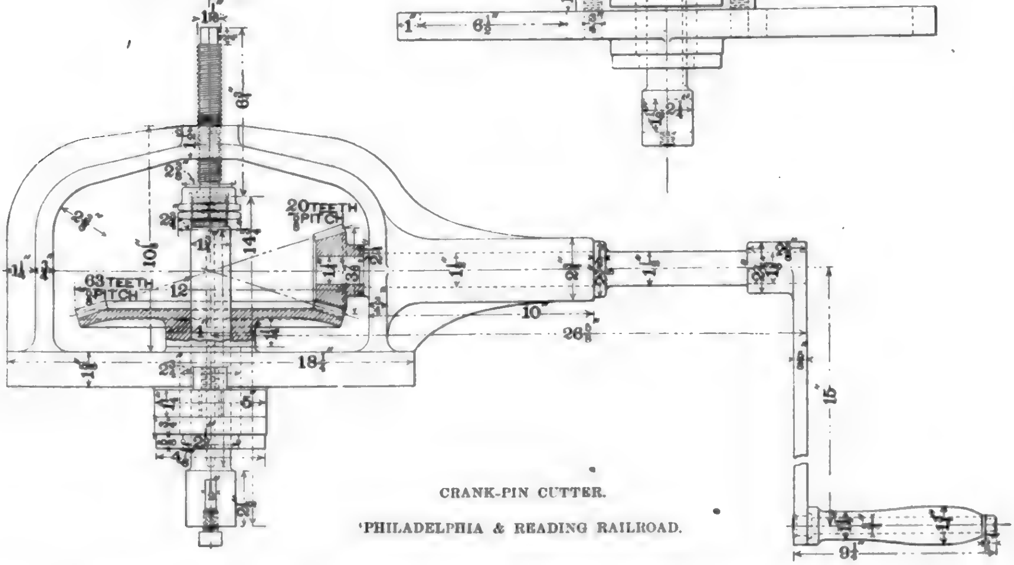
SPECIAL TOOLS AT THE READING SHOPS OF THE PHILADELPHIA & READING RAILROAD.

CRANK-PIN CUTTER.

EVERY master mechanic and workman in shops has experienced the trouble which is always found with the cutting out of the crank-pins which have become worn, or which, for any other reason, it is necessary to remove from the wheels. The machine which we illustrate is a very simple device, operated by hand, for doing this work. When the pin has been pressed into the wheel and riveted over on the inside it is difficult to get at with the cold chisel, and it sometimes necessitates the removing of a portion of the other operating mechanism. The tool which we illustrate is very clearly shown, both in the drawings and the dimensions on the same. It is bolted through the 1-in. slots to the back of the wheel or to the frame of the engine, the latter being the most suitable position. This allows freedom for the motion of the handle. The tool is placed in the tool holder at the lower end of the spindle, and is fed down to its work by the feed-screw at the top, slipping through the beveled gear which is driven by the pinion; thus, after the machine is in position it is the work of but four or five minutes to cut out the riveting at the back of the pin, and make it perfectly free for being driven out with the ram or pulled out with the hydraulic pressure. There is no cutting out of the back of the wheel, which is left in perfect shape for the placing of the new pin, and its subsequent riveting. The handle, which is 15 in. long from center to center, driving a pinion which is geared up with a little over 8 to 1 for the driving-gear, gives ample power, and the check nuts on the spindle serve to take up the lost motion and keep a perfect alignment.







CRANK-PIN CUTTER.

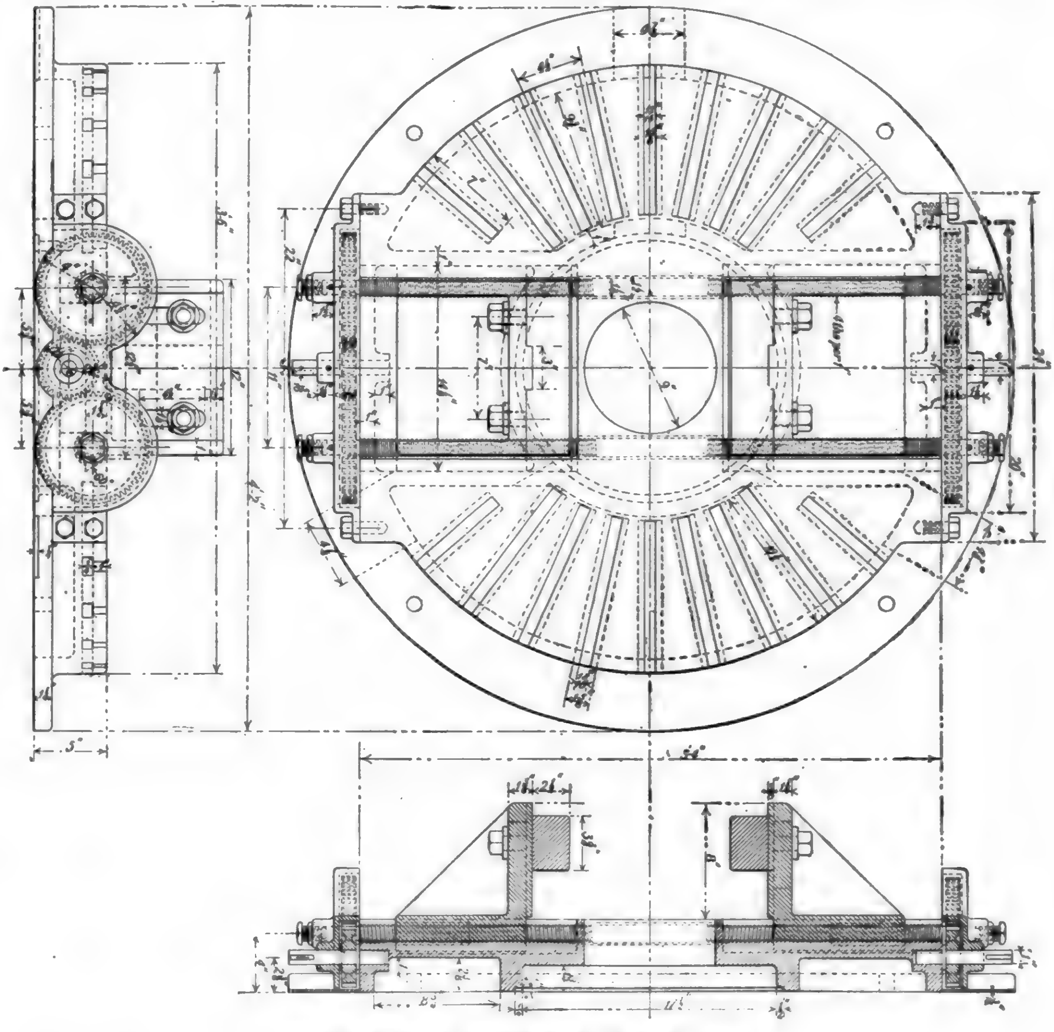
PHILADELPHIA & READING RAILROAD.

DRIVING-BOX CHUCK.

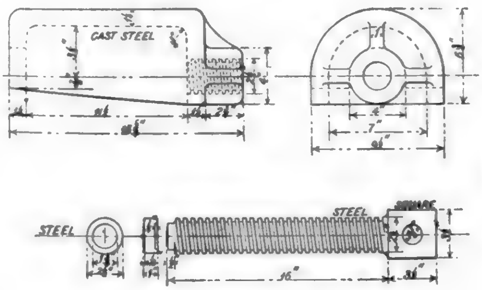
One of the handy arrangements, and one which has served to cut down expenses very materially in the shop, is an attachment for a wheel-borer that is used for boring out driver-box brasses. This is shown very clearly in fig. 12. It consists of a chuck which is bolted to the face plate of the machine, having two screws on one side for drawing the jaws of the chuck together symmetrically, and so that there is no difficulty in centering the box, which is merely dropped into the chuck, which is screwed up tight and the machine started. A driving box can be bored out in this way in about an hour, the actual time of boring being somewhat less, as the capacity of the machine is 10 for 10 hours' work, including the time consumed in changing tools, etc. Provision is made for adjusting the sides of the jaws of the box so that they will always draw true by the screw which is shown at the ends of the main screws, which is a tightening screw by which the main screws can be thrown slightly ahead or allowed to come back, as the case may require. Of course, such an adjustment as this is only needed after considerable wear has taken place, and it is done very rarely. It is simply necessary that the man who has charge of the machine should see that his boxes are held centrally by the two jaws of the chuck by an occasional inspection.

PISTON-ROD JACK.

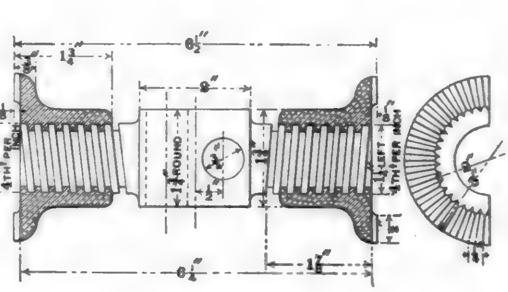
The accompanying illustration shows the construction of a very simple piston-rod jack, which was especially designed



CHUCK FOR BORING DRIVING BOXES ON WHEEL-BORER.



PISTON-ROD JACK.



CAR INSPECTOR'S JACK.

Special Tools on Philadelphia & Reading Railroad.

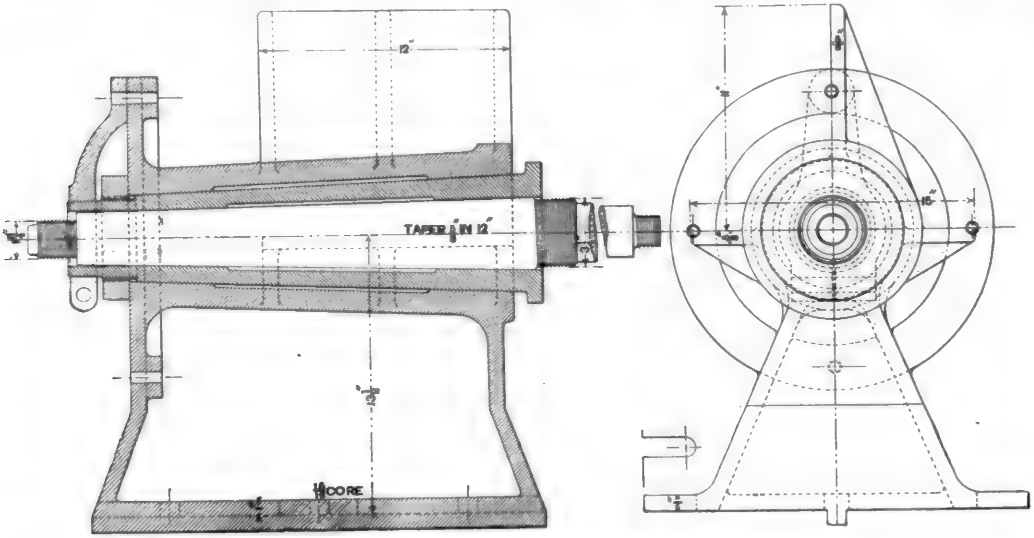
for taking the piston-rods out of the cross-heads of the compound locomotives. A steel screw, $2\frac{1}{4}$ in. in diameter, with a cast-steel nut that slips over the cross-head constitute the whole affair. When the nut is in the screw is simply driven down with an ordinary jack-screw bar, pressing the piston-rod on ahead of it, and forcing it out without any danger and without mutilating it in the slightest. A steel cap fits over the end of the screw, so that there is no turning of the screw against the end of the piston-rod and consequent mutilation of the center.

JACK FOR CAR INSPECTORS.

Every car inspector needs a small, light jack for occasional use, especially where it is necessary to remove brasses from the oil-boxes and similar work. The jack which we illustrate is a very simple little double-ended affair, that is made at the Reading shops for the use of the car inspectors along the road. The outside diameter of the screw is $1\frac{1}{4}$ in., and it is cut with four threads to the inch. The caps, which are also the nuts, are toothed, so that there is no danger of slipping, and the weight is reduced to the smallest possible amount by the fact that it consists merely of the two nuts and the screw itself. The working part of the screw being in the center brings it so far below the bottom of the box that it can be readily seen and operated.

CROSS-HEAD CHUCK.

Any one who has had experience with planing off cross-heads, especially where they are obliged to do it in large quantities, knows the desirability of obtaining some methods of holding them so that they can be planed true and square under all circumstances, and that the work can be readily adjusted in the machine. The chuck which we illustrate was designed at the Reading shops, and is giving most satisfactory results. In explanation of the same, it will be seen that there is a taper spindle which enters the main spindle, and is held up in position by nuts and screws, and at the outer end of this there is a taper over which the cross-head is fastened and to which it is keyed. There are two flat surfaces at right angles to each other, as shown in the illustration, which serve as the lining points for the cross-heads. When the chuck is in position these are square with the plates of the planer, and the cross-head, after being keyed into position, is turned with the spindle, so that its two faces are true with these two squares, and when it is desired to turn it 90° for the sake of planing the edges or the wearing surfaces, the whole is turned and held in position by means of pins which slip through the holes which are shown, both in the cross-section and in the rear elevation. It is strong and substantially made, and any one copying it exactly from the dimensions given will find that they have a planer tool of great value for doing this one particular class of work.



CROSS-HEAD CHUCK, READING SHOPS, PHILADELPHIA & READING RAILROAD.

PRESIDENT HAINES, OF THE AMERICAN RAILWAY ASSOCIATION, ON THE LABOR QUESTION.

In his address before the Association, of which he is President, Mr. H. S. Haines discussed the labor question at considerable length. He suggests the incorporation of the labor unions as a means of imposing responsibility on them for the fulfilment of contracts which they might make for their members. This proposal brings a sad smile on the faces of some of us, who contended now so many years ago for the right of the men to be heard through their representatives. The indignant and often insolent refusal of some employers to "recognize" a committee of the men has probably done more than any other one thing to foment strikes. It has been observed in Europe as well as here that strikes are rare when trades unions grow rich. The members of such associations soon discover that their funds are soon dissipated by a strike, and therefore, as soon as they accumulate a large fund, they desist, or at least try to avoid strikes. Unions which indulge in the luxury of strikes don't get rich, and, conversely, those which are rich don't strike.

In his address, President Haines said:

"The proper way to adjust such differences is by agreement—by an agreement between contracting parties, competent and responsible. As to the competency and responsibility of one party—the railroad company—there is no doubt; but as to the other—the employé—he as an individual possesses neither qualification. As well stand on the river's brink and seek to enter into an agreement with the current swiftly flowing by, a constant succession of drops of water, as to make a contract with a changing force of men, coming and going as each sees fit.

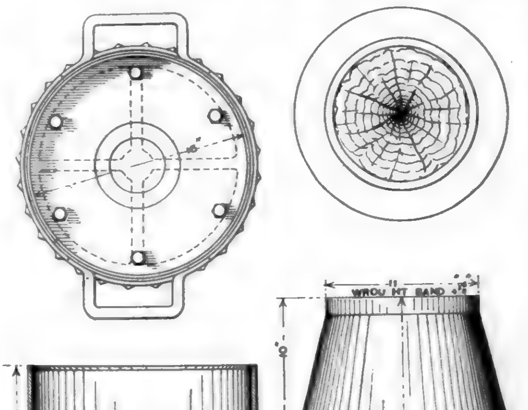
"The very organizations which they have made for self-protection may be made the means for enforcing their contract obligations. To this end they should be duly incorporated under such restrictions as will insure their legal competency to contract on behalf of their members. The responsibility for keeping these contracts will then rest with their incorporated organizations, which can, by assessment, accumulate a fund that can be invested safely where it can be reached in a suit for damages for breach of contract. There will then be no voluntary arbitration, to be viewed askance by Bench and Bar, but the same legal procedure will be available to secure an observance of contract relations between railroad corporations and workmen's corporations that apply to other business con-

tracts. The legal recognition of such agreement will be a great step toward the preservation of harmonious relations between the two parties and the assurance to the public of uninterrupted railroad service.

"A failure to agree upon the terms of a mutually satisfactory contract would still be possible, but only in the event that the employés of each class were able to combine in single corporations. Past experience leads us to believe that this could not be done; that either from personal ambition or from other causes there would be independent corporations of workingmen that would compete for contracts with desirable railroad corporations, and that in this way it would always be practicable to arrive at an agreement with one or another."

HOISTING TUB OF THE DELAWARE & HUDSON CANAL COMPANY'S RAILROAD.

Among the useful hydraulic tools which we have been illustrating from the Delaware & Hudson Canal Company's Road, is this hydraulic jack or hydraulic tub, as it is called in local parlance, for use in hoisting cars. It consists of a boiler-plate shell riveted up with a butt joint so that the interior is smooth. The piston is made with a long leather packing, as shown in the engraving, and the bottom has an opening into which a ¾-in. pipe is screwed. The outer end of this pipe has a hose connection, which may be connected with the hose leading to the hydraulic pressure pipes which are carried all over the shop. When a car is to be hoisted one of these tubs is rolled along the floor like a barrel and put into position. The oak piston is dropped into the tub and water admitted from the lower side. With this arrangement there is a hoist of about 18 in., and inasmuch as the base of the tub is nearly 18 in. in diameter, and the bearing on the top of the plug against the car is 11 in. in diameter, there is a steady support, and when the car is up and off the wheels there is no necessity for

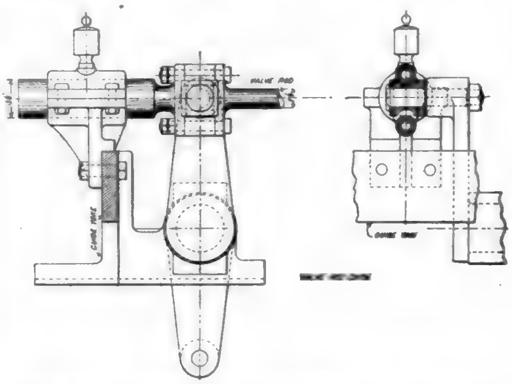


HOISTING TUB, DELAWARE & HUDSON CANAL COMPANY'S RAILROAD.

any bracings. There are a number of these scattered around the shop, and they are used exclusively instead of hydraulic jacks. Of course when a car is ready and the supply of tubs falls short, the car is simply lowered upon a horse and the tubs rolled away to be used in another place. The cheapness and effectiveness of this little convenience will certainly recommend it to all who have an hydraulic power available. The pressure which is used under these tubs runs from 40 to 50 lbs. per square inch.

VALVE-ROD GUIDE, DELAWARE, LACKAWANNA & WESTERN RAILROAD.

We illustrate a form of valve-rod guide which is being introduced upon a number of engines of the Delaware, Lackawanna & Western Railroad, by Mr. David Brown, who is Master Mechanic at the Scranton shops. Every one has experienced the difficulty which appears with the use of the valve rod rigidly attached to the rocker-arm as it is ordinarily applied. The vertical motion of the arm causes a spring to the rod, and this of course has a wearing effect upon the packing, causing it to blow.



The arrangement which Mr. Brown has designed is old in theory and has been applied in one form or another to locomotives before, but the particular arrangement which he uses is very simple and compact, and is giving such excellent results that we reproduce the drawings from which the work was made. The rocker arm is made in the usual way, and with the pin of identically the same shape as that which is used for the ordinary valve stem. The valve stem terminates, however, in a yoke, and has an extension rod which is 3¼ in. in diameter for a 1½-in. rod. This extension passes through a bearing which is bolted to the guide yoke and holds the rod rigidly in a horizontal position. The rocker pin at the end of the upper arm passes through a brass box which slides up and down in the yoke on the valve stem, so that the rod is given a plain horizontal direction and the slight vertical motion of the upper end of the arm is taken up by the sliding of the brass box in this yoke. The box is made solid and is slipped over the pin. The wear of the box can very readily be taken up by planing off metal or removing liners from the yoke, the same as is done with links.

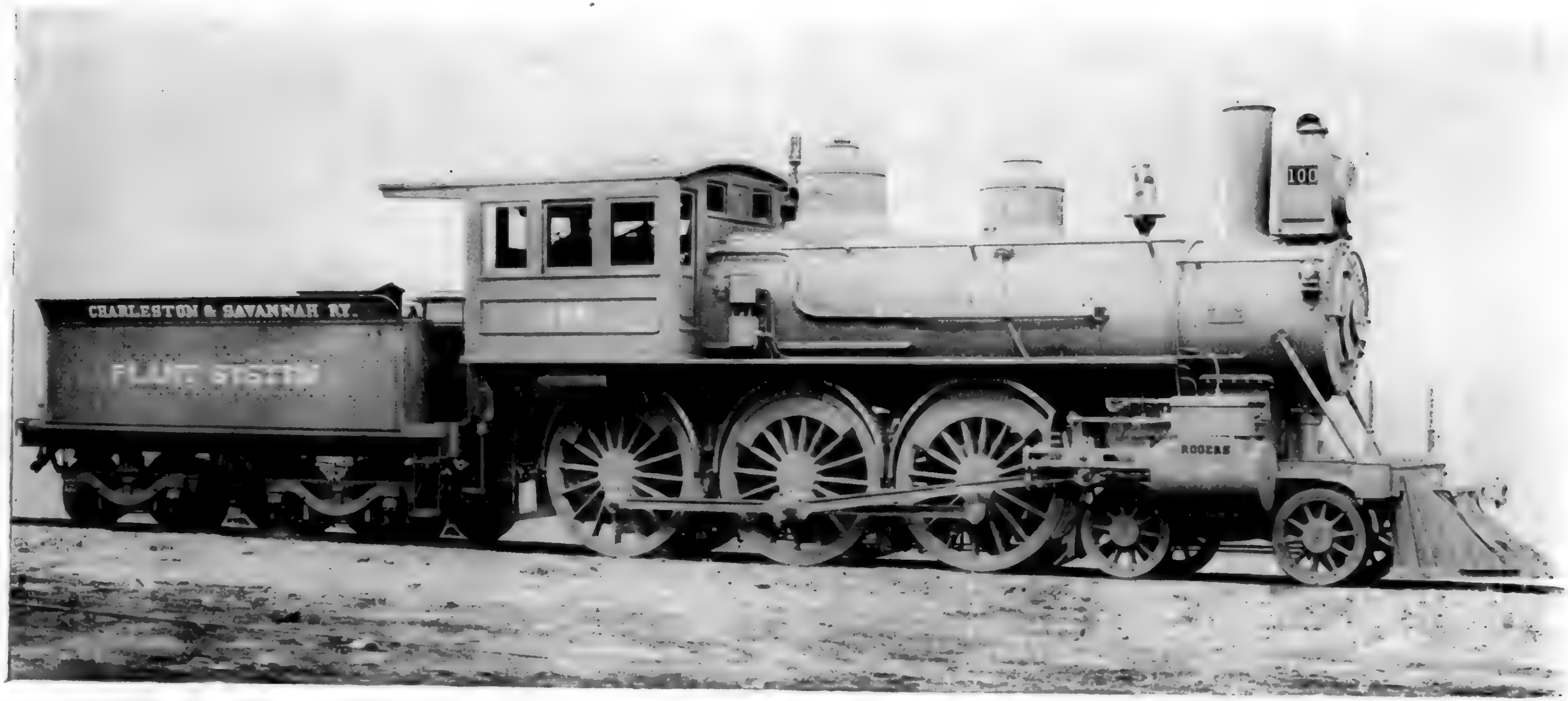
THE CORINTH CANAL.

In reporting the opening of this canal in August last, our Consul at Athens gives the following interesting particulars about this great work:

"The feasibility of piercing the Isthmus of Corinth by a canal was conceived six hundred years before the Christian era.

"It was Nero who came nearer to effecting the modern realization than any other of the ancients. In the year 67 he put 6,000 Jewish prisoners and other laborers at work upon the isthmus. These were directed with so much zeal and energy that the successful termination of the task was in sight from its very beginning. But a revolt against Nero followed soon after, ending in the death of the tyrant and the abandonment of his projects.

"In 1881 General Türr was granted by the Greek Government the concession of digging a canal through the Isthmus of Corinth. The aid of French capital was enlisted, and the modern canal was begun over the route chosen by Nero. As General Türr himself says:



TEN-WHEELED LOCOMOTIVE. BUILT BY THE ROGERS LOCOMOTIVE COMPANY, PATERSON, N. J.

"'It is the canal commenced by Nero and abandoned during eighteen centuries that we have finished to-day, in accordance with conditions and dimensions suitable to modern navigation.'

"The original company which General Türr organized passed out of existence, and another one was formed by him. The capital of the present company is 5,000,000 francs, divided into 10,000 shares of 500 francs each. It is estimated that the annual transit through the canal will amount to 4,500,000 tons, paying one franc from the Adriatic and 50 centimes from elsewhere; one franc will be charged for each person. The canal is 6,540 meters long, 21 meters wide at the bottom and 21.6 meters at the surface, and 8 meters deep. The lease extends for 99 years, and at its expiration the canal becomes the property of the Greek Government on the payment of 5,000,000 francs to the company.

"The Corinth Canal will abridge by 185 nautical miles the route of vessels from the Adriatic bound for Constantinople, and will effect a saving of 95 miles in the case of vessels from Mediterranean ports. It will obviate the necessity of making the dangerous passage around Cape Matapan, and is expected greatly to facilitate commerce between Europe and the East. Austrian commerce, and chiefly the port of Trieste, will profit by it."

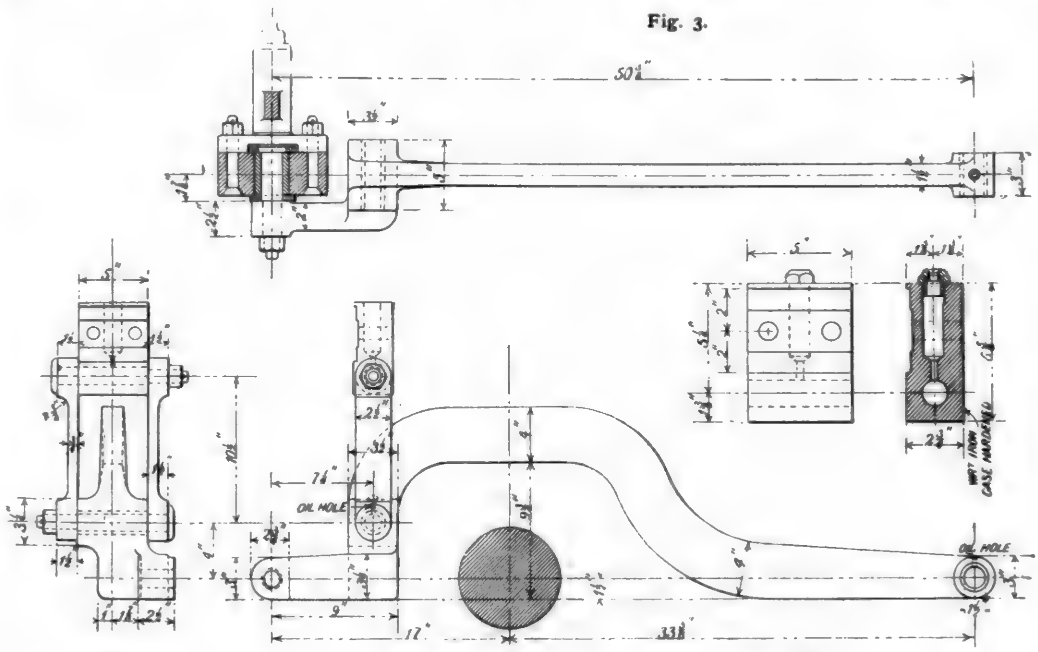


Fig. 3.

Fig. 2. Fig. 1.

DETAILS OF VALVE GEAR OF TEN-WHEELED PASSENGER LOCOMOTIVE, BY THE ROGERS LOCOMOTIVE COMPANY.

TEN-WHEELED PASSENGER LOCOMOTIVE.

The full page engraving herewith represents one of the locomotives exhibited by the Rogers Locomotive Company at the Chicago Exhibition. It is an excellent example of a type of heavy passenger engines which of late years have been adopted on lines on which train loads have grown beyond the capacity of eight-wheeled engines.

The fire-box is intended for burning bituminous coal, and is placed on top of the frames, the crown-sheet being stayed with radial stays. The springs are underhung.

On a 10-wheeled engine of this kind there is always more or less difficulty in connecting the links with the rocker-shafts. This has been overcome by a very neat design of the various parts of the valve-gear. Separate engravings of these parts are given which show very clearly how they are constructed. Fig. 1 is a side view of one of the radius bars, which is connected to the rocker at its right-hand end and to the link by the other end. This bar, it will be seen, is bent so as to clear the front driving-axle, which comes between the link and the rocker. The back end of the radius bar next to the link is suspended by two pendulum bars or links, shown clearly in the side view, fig. 1, and in the end view, fig. 2. From the plan, fig. 3, it will be seen that the back end of the radius bar is off-set and is attached to the link-block on one side, just as the lower rocker-arm usually is. The link is then suspended on the opposite side in the usual way.

The following are the principal dimensions and weights of this engine:

Weight of engine in working order	133,000 lbs.
" on driving-wheels " "	98,500 "
" of tender " "	80,000 "
Total wheel base of engine and tender	52 ft. 2 in.
" " " " "	24 ft. 8 in.
" driving wheel-base	13 ft. 6 in.
Diameter of cylinders	19 in.
Stroke of pistons	24 in.
Diameter of driving wheels	72½ in.
Total heating surface	1,968 sq. ft.
Heating surface in tubes	1,815 " "
" " " fire-box	153 " "
Grate area	31.38 sq. ft.
Steam pressure per square inch	170 lbs.
Water capacity of tank	3,500 galls.
Coal capacity	7 tons.

MECHANICAL SCIENCE.

In an address delivered recently before the Mechanical Section of the British Association by Mr. Jeremiah Head, the President of that section, he attempted to show that mechanical science is largely indebted to mechanisms as they exist in nature, if not for its origin, at all events, for much of its progress hitherto, and that nature must still be our guide.

Mechanical science, he said, had been built up entirely upon observation and experiment and the natural laws which had been induced therefrom by man. Many if not most animals could be taught to use mechanisms if carefully trained from

infancy. Thus the well known donkey at Carisbrooke Castle drew water from a deep well by a treadmill arrangement just as well as a man could do it. He had seen a canary gradually lift from a little well, situated a foot below its perch, a thimbleful of water by pulling up with its beak, bit by bit, a little chain attached to it, and securing each length lifted with its foot till it could take another pull. When the thimble reached its perch level the bird took a drink, and then let it fall back into the well. Mr. C. Wood, of Middlesbrough, informed him that certain crows which frequented oyster-beds on the coast of India waited until the receding tide uncovered the oysters, which still remained open for a time. A crow would then put a pebble inside one, and, having thus gagged it and secured his own safety, would proceed to pick it out and eat it at leisure. A monkey would crack a nut between two stones, and would hurl missiles at his enemies. But in some countries he was systematically entrapped by tying to a tree a hollow gourd containing rice, and having a hole large enough for his hand, but too small for his clenched fist, to pass through. He climbed the tree and grasped the rice, and remained there till taken, being too greedy and not having sufficient sense to let go the rice and withdraw his hand. All animals were in their bodily frames, and in the intricate processes and functions which went on continuously therein, mechanisms of so elaborate a kind that we could only look and wonder and strive to imitate them a little here and there. The mechanical nomenclature of all languages was largely derived from the bodies of men and other animals. Many of our principal mechanical devices had pre-existed in them. Mr. Head proceeded to consider how far man was in his natural condition, and had become by aid of mechanical science, able to compete successfully with other and specially endowed animals, each in his own sphere of action. The bodily frame of man was adapted for life and movement only on or near to the surface of the earth. Without mechanical aids he could walk for several hours at a speed which was ordinarily from 3 to 4 miles per hour. Under exceptional circumstances he had accomplished over 8 miles in one hour and an average of 2¾ miles per hour for 141 hours. In running he had covered about 11¼ miles in an hour. The power of the living human mechanism to withstand widely diverse and excessive strains was altogether unapproachable in artificial constructions. Thus, although fitted for an external atmospheric pressure of about 15 lbs. per square inch, he had been able, as exemplified by Messrs. Glaisher and Coxwell in 1862, to ascend to a height of 7 miles and breathe air at a pressure of only 3½ lbs. per square inch, and still live. And, on the other hand, divers had been down into water 80 ft. deep, entailing an extra pressure of about 36 lbs. per square inch, and had returned safely. One had even been to a depth of 150 ft., but the resulting pressure of 67 lbs. per square inch cost him his life. No animal burrowed downward into the earth to a greater depth than 8 ft., and then only in dry ground. The horse, though he could not walk faster than man, nor exceed him in jumping heights or distances, could certainly beat him altogether when galloping or trotting. A mile had been galloped in 103 seconds, equal to 35 miles per hour, and had been trotted in 124 seconds, equal to 29 miles per hour. How man's position as a competitor with other animals in speed was affected by his use of mechanical aids, but without any extraneous motive-power, was considered in reference to locomotion on land, in water, and in air. But the most wonderful increase to the locomotive power of man on land was obtained by the use of the modern cycle. One mile had been cycled at the rate of 27.1 miles per hour, 50 at 20, 100 at 16 6, 388 at 12.5, and 900 at 12 43 miles per hour. Unaided by mechanism man had shown himself able to swim for short distances at the rate of three, and long distances (22 miles) at the rate of 1 mile per hour. He had also given instances of being able to remain under water for 4½ minutes. Credible eye-witnesses stated that porpoises easily overtook and kept pace with a steamer going 12½ knots, or, say, over 14 miles per hour, for an indefinite length of time. This was five and 15 times the *maximum* swimming speed of a man for short and long distances respectively. The fastest mechanism of any size, animal or man-made, which had ever cut its way through the waters for any considerable distance, was the torpedo-boat *Ariete*, made by Messrs. Thornycroft & Son, of London, in 1887. By inventing and utilizing mechanical contrivances, entirely independent of his own bodily strength, man could now pass over the surface of the waters at the rate of over 500 knots per day, and at the same time retain the comforts and conveniences of life as though he were on shore. He had in this way beaten the natural and specially fitted denizens of the deep in their own element, as regarded speed and continuity of effort. But he was still behind them as to safety. We did not find that fishes or aquatic mammals often perished in numbers as man did by collisions in fogs, or by being cast on lee shores and rocks by stress of weather. Should we ever arrive at the point of making ocean traveling absolutely safe? In one way the chances of serious disaster had been of late largely diminished, and here, again, nature had been our teacher. The bodies of all animals except the very lowest were symmetrically formed on either side of a central longitudinal plane. Each important limb was in duplicate, and if one side was wounded the other could still act. The serpent, having no limbs whatever, would seem at first sight to be terribly handicapped; yet, in the language of the late Professor Owen, "it can out-climb the monkey, out-swim the fish, out-leap the jerboa, and, suddenly loosing the close coils of its crouching spiral, it can spring into the air and seize the bird on the wing." Here we had the spiral spring in nature before it was devised by man.

The decisive victories which in modern times man had gained over matter and over other animals had been due to his use of power derived from other than animal sources. That power had invariably proceeded from the combustion and the destruction of fuel, the accumulations of which in the earth were necessarily limited. Mechanical appliances, involving the consumption of fuel, had for a century at least been multiplying with alarming rapidity. Our minds had been set mainly on enlarging the uses and conveniences of man, and scarcely at all on economizing the great sources of power in nature, which were now for the most part its fuels. Terrible waste of these valuable stores was daily going on in almost every department of use. Once exhausted they could never be replaced. They had been drawn upon to some extent for 1,000 years, and extensively for more than 100. Authorities said that another 1,000 years would exhaust all the more accessible supplies. But suppose they last 5,000 years, what then? Why, then, as far as we could at present see, our only motive powers would be wind and water and animals, and our only mode of transit, sailing and rowing, driving, cycling, riding, and walking. Sir Robert Ball had estimated that in not less than 5,000,000 and not more than 10,000,000 years the sun would have become too cold to support life of any kind on this planet. Between the 5,000 years when fuel would certainly be exhausted and the 5,000,000 years when all life might be extinguished, there would still be 4,995,000 years when, according to present appearances, man would have to give up his hardly earned victories over matter and other animals, and the latter would again surpass him, each in its own element, because he had no fuel.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

V.—METHOD OF DETERMINING SULPHUR IN PIG AND WROUGHT IRON.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page 445, Volume LXVII.*)

OPERATION.

Put 5 grams of the borings into a beaker whose bottom is about 3 in. in diameter, add 40 c.c. of concentrated C. P. nitric acid, and cover with a watch glass. If action takes place immediately with foaming, put the beaker in cold water until the action is modified somewhat. If action does not start at once after addition of acid, warm to start the action, and then, if necessary, put the beaker in cold water until the violence of the action has passed. As soon as quiet action is obtained, add about half a gram of pulverized chlorate of potash, keeping the beaker still covered, and put on the steam table. After all effervescence has ceased, set the cover up on a glass triangle and evaporate to remove free nitric acid until the material in the beaker will no longer adhere to a glass rod. Remove now from the steam table, allow to cool, and add 30 c.c. of concentrated C. P. hydrochloric acid, cover the beaker with a watch

glass, and heat until solution is complete, and then set the cover up as before and evaporate to dryness to render silica insoluble. A temperature not below 250° F. should be used, and the drying should be continued until only faint odor of HCl. is perceptible. Allow to cool and then add 20 c.c. concentrated C. P. hydrochloric acid, heat covered until solution is complete, and then evaporate the free acid until a skin begins to form over the top of the material in the beaker. As soon as this skin appears, add 5 c.c. concentrated C. P. hydrochloric acid and 25 c.c. of water, heat to boiling to insure solution, filter, and wash with water until the filtrate and washings amount to 100 c.c. Add now to the filtrate 10 c.c. barium chloride solution, heat to boiling to granulate the precipitate, then remove from the heat, allow to cool slightly, and add 100 c.c. of 95 per cent. alcohol. Stir thoroughly, cover with a watch glass and allow to settle until the solution is clear. Filter through a 7 centimeter filter, wash with hot water until the washings no longer react for chlorine with silver nitrate, transfer the wet filter with the barium sulphate on it to a weighed half-ounce platinum crucible, "smoke off" the filter, ignite and weigh. Add now to the crucible about half a gram of C. P. carbonate of soda and a crumb of C. P. nitrate of potash about the size of half a kernel of wheat, and fuse with the cover on until the material in the crucible is quiet. Treat the material in the crucible with hot water and wash out into a small beaker, taking pains also to detach anything adhering to the cover. Warm or boil the liquid in the beaker to insure complete solution of the sulphate of soda, filter through a small filter, wash with hot water until a drop of the filtrate shows no reaction with turmeric paper, and then two or three filtersful more. Now cover the beaker with a watch glass, add by means of a pipette through the nose of the beaker concentrated C. P. hydrochloric acid until the liquid is just acid to litmus paper; then add three drops more of acid and 5 c.c. of barium chloride solution and bring to boiling, keeping covered to avoid loss by effervescence. Remove from the heat, allow to settle, filter, wash, ignite wet, and weigh as before described.

APPARATUS AND REAGENTS.

The apparatus required by this method presents no peculiarities and requires no especial description. Since one of the directions requires that the material shall be evaporated until a skin begins to form, it is probable that more uniform results will be obtained by different operators and in different tests if the evaporation is done with the same surface exposed in all cases. It is accordingly specified that this evaporation shall be done in a beaker whose bottom is about 3 in. in diameter.

The nitric, and hydrochloric acids, the chlorate of potash, and the carbonate, and nitrate of soda are the C. P. materials such as are obtained in the market.

The chloride of barium solution is made by adding 100 grams of the C. P. salt to 1 liter of distilled water, allowing to dissolve and filtering before use.

The alcohol is the ordinary commercial 95 per cent. material of the market.

CALCULATIONS.

Since the sulphur is 13.73 per cent. of the weight of the barium sulphate, if the weight obtained expressed in grams is multiplied by 13.73 and the product divided by 100, the quotient will be the sulphur expressed in grams. Then, since the estimation is made on 5 grams, the percentage of sulphur in the steel will be shown by removing the gram decimal point two places to the right and dividing by 5, thus:

If the weight of barium sulphate found is 0.0259 gram, the sulphur is $\frac{0.0259 \times 13.73}{100} = 0.00355$ gram, and the percentage of sulphur in the steel $\frac{0.355}{5} = 0.071$ per cent.

NOTES AND PRECAUTIONS.

This method, as will be observed, oxidizes the sulphur in the iron principally, and perhaps wholly, by means of nitric acid, converts the nitrate of iron formed into chloride by means of hydrochloric acid, separates silica by evaporation to dryness after the material is converted into chlorides, and precipitates the sulphuric acid in presence of the chloride of iron by means of barium chloride, using alcohol to effect the separation of the last traces of barium sulphate from the solution. It seems probable that the chlorate of potash, which is added principally in order to have a little alkaline base for the sulphuric acid to combine with and thus prevent possibility of loss during the evaporation to dryness, may possibly assist the oxidation of the sulphur. Furthermore, the first evaporation to expel the excess of nitric acid rarely removes it all, and the subsequent addition of hydrochloric acid to expel the nitric forms with this remnant of the nitric a little aqua regia, which may still further render the oxidation of the sulphur secure.

It is essential before making a determination that not less than two blanks should be made, using all the chemicals in the prescribed amounts and conducting the whole operation just as for a regular analysis, except that no iron is present. The weight of barium sulphate obtained as the result of these two determinations, which should not differ more than half a milligram, must be deducted from the weight of the barium sulphate obtained in the regular analysis of a wrought or pig iron It is recommended to set aside, for use in sulphur determinations only, a bottle of each of the chemicals used in making the blanks. Of course the figures obtained will be available as long as these bottles last.

It is obvious that if the air of the laboratory is contaminated with H_2S or SO_2, or even sulphuric acid fumes from ignitions and evaporations, there will be danger of too high results from contamination of the liquid in the beaker from the two gases while the evaporations to dryness are going on, and at all times during the manipulation of the material in the open beaker from the sulphuric acid fumes. We have never proven how great this danger is, but it may possibly help to explain some anomalous results.

It will be observed that after the evaporation to dryness to render silica insoluble, it is directed to add 20 c.c. of concentrated C. P. hydrochloric acid; then this acid is evaporated until a skin forms and then 5 c.c. of concentrated C. P. hydrochloric acid is again added. This looks like unnecessary complication. The reason for this manipulation is that 20 c.c. of concentrated C. P. hydrochloric acid is about the least amount that will take up the soluble material in the beaker after evaporation to dryness. But this is too much free acid to be present when precipitating with chloride of barium; also, in order to secure uniform results, the precipitation must be done in presence of a moderately definite amount of free acid. The removal of the excess and the securing of the definite amount of free acid are believed to be more certainly accomplished by the method described than by the attempt to evaporate in a beaker to a definite volume. Moreover, in attempting to evaporate to a definite volume it not infrequently happens from local overheating, since the bottoms of all beakers are not flat, that basic or semi-basic salts are formed that will not dissolve in water. Only careless manipulation will lead to this result with the method described.

It sometimes happens that 20 c.c. of concentrated C. P. hydrochloric acid is not enough to take up everything soluble after the evaporation to dryness. In this case more acid and longer continued heating must be employed. This excess of added acid must of course be evaporated until the skin appears, as already described.

It is well known that sulphates are insoluble in alcohol, and accordingly an equal volume of alcohol is added to the chloride of iron solution to secure, if possible, a complete separation of the barium sulphate. Direct experiments show that with this manipulation about 2 milligrams more barium sulphate are obtained than if the alcohol is omitted. This is equivalent to a difference of a little over half a hundredth per cent. (0.005 per cent.). Practically the same results were obtained when one-third, one-half and two-thirds of the bulk of the solution was alcohol.

Barium sulphate is liable to be reduced during the ignition of the filter, and thus lead to slightly low results. To obviate this difficulty the filter and precipitate are put into the crucible wet, and the filter "smoked off" and then burned. The "smoking off" consists in applying the heat to the wet material in the crucible so slowly that the volatile matter of the filter passes off without ignition, free access of air being maintained at the same time. To accomplish this, fold up the wet filter and place it in the crucible. Put the crucible on the triangle, as in ordinary ignitions, and leave the cover off. Then heat the open end of the crucible slowly. The filter and precipitate gradually dry, and soon the parts of the filter in contact with the crucible begin to distill off the volatile matter at low heat, even before the whole is dry. This process goes on if the flame is properly adjusted, until in a little while everything that is volatile at a low temperature has passed away, and the precipitate, with a black envelope of carbonaceous matter, is left. When this is the case the temperature can be raised, the lamp moved back to heat the bottom of the crucible, and the carbon burned off completely. Usually when the temperature is raised the black envelope of carbonaceous matter falls away from the precipitate and is rapidly consumed. By this method of ignition the material is a little longer time in the crucible than with the old method of previ-

ously dried precipitates, but the danger of reducing the precipitate is believed to be very much diminished.

It will be observed that directions are given to weigh before the barium sulphate is purified by fusion with carbonate of soda. This may seem unnecessary manipulation, but it is believed that this check on serious error arising during the fusion and subsequent operations is worth all it costs. If the manipulation as described is carefully followed, if the amount of barium sulphate is not large, and especially if it shows no tinge of color after the first ignition, the amount of barium sulphate obtained after the fusion differs so little from the first weight that the error can be ignored, and the question fairly arises whether the fusion may not in general be omitted. On the other hand, if the ignited barium sulphate is colored, showing presence of iron, or if the "smoking off" of the filter is carelessly managed, resulting in reduction of some of the barium sulphate, quite serious errors may result from omitting the fusion. Also if the silica is not all rendered insoluble by the evaporation to dryness, some of it may appear with the barium sulphate on the first weight. By far the largest portion of this is removed by the fusion, so that when the highest accuracy is required the fusion should not be omitted. The addition of the little crumb of potassium nitrate to the fusion is to ensure the oxidation of any reduced barium sulphate which may have been formed while "smoking off" the filter.

The examination of a number of samples of the graphitic residue and silica obtained as the result of the first filtration shows only traces of sulphur in this residue, and it is questionable whether even these traces did not come from the gas flame used in burning off the graphite.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 535.*)

The Conference on Aerial Navigation in Chicago in August, 1893, brought out a number of experimenters whose ventures had theretofore been unpublished.

One of these, Mr. *E. C. Huffaker*, of Tennessee, had been experimenting with a model somewhat resembling the "effigy" of Mr. *Lancaster*. It consisted in a rectangular surface of fabric made concavo-convex by a rigid front spar with curved ribs at right angles thereto, so as to resemble the cross section of a soaring bird's wing. A cross stick attached thereto carried a balancing horizontal tail, the center of gravity being determined at the front by loading with lead. The area of sustaining surface was 2 sq. ft., and when held by the cross stick at arm's length overhead, vibrating between two fingers and facing a wind of 35 miles per hour (6 lbs. pressure at right angles), the weight sustained (or lift) was estimated at 2 lbs. to the square foot, or that corresponding to an angle of 10° upon a flat plane, while in point of fact the model seemed to be horizontal, and the force required to hold it in the wind was very small.

When the model was let go in a steady breeze it would rise to a height of 12 or 15 ft., slowly retreating from the wind, but always facing it; then, tipping slightly forward, it would descend into the face of the wind; all these effects being easily explained in a horizontal current.

When projected forward by hand, the model would sail away in steady flight with a velocity of about 17 miles per hour, and then descend on a gradient of about 1 in 15. If thrust rapidly forward it would rise some 8 or 10 ft., and then, hanging suspended for a moment, it sailed forward to the ground.

These experiments are interesting as confirming what has hitherto been said concerning the greater lift appertaining to concavo-convex surfaces, and it is to be hoped that they will be continued.

The other experimenter was Mr. *J. J. Montgomery*, of California. He had, some years previously, constructed a soaring apparatus, consisting of two wings, each 10 ft. long by an average width of 4½ ft., united together by a framework to which a seat was suspended, and provided with a horizontal tail which could be elevated or depressed by pulleys. The wings were arched beneath, like those of a gull, and afforded a sustaining area of about 90 sq. ft. The weight of the apparatus was 40 lbs., and that of the experimenter some 130 lbs. more.

Mr. *Montgomery* took this apparatus to the top of a hill nearly a mile long, which gradually sloped at an angle of about 10°, and placing himself within the central framework, the rods of which he grasped with each hand, ready to sit down, he faced a sea breeze steadily blowing from 8 to 12 miles an hour, and gave a jump into the air without previous running.

He found himself at once launched upon the wind, and glided gently forward, almost horizontally at first, and then descended to the ground, finding that he could meanwhile direct his course by leaning to one side or the other. The total distance glided was about 100 ft., and the sensation was that of firm yet yielding and soft support, being quite similar to the experience of M. *Mouillard*, as already described, except that there was no apprehension of disaster.

Mr. *Montgomery* carried his machine back to the top of the hill and prepared to repeat the experiment, but as soon as he got into position the apparatus began to sway and to twist about in the wind; one side dipped downward, caught on a small shrub, and, as quick as a flash, the operator was tossed some 8 or 10 ft. into the air, overturned, and thrown down headlong. He fortunately fell without serious injury, and found, as soon as he recovered himself, that one side of his machine was smashed past mending.

This experience led him to design and build a second soaring apparatus, in which he endeavored to relieve undue pressure upon either side by providing a diagonal hinge in each wing, along which the rear triangle might fold back (it was restrained by a spring) and yield to a wind gust. This apparatus measured some 132 sq. ft. of sustaining surface, and weighed 45 lbs. It was not successful; several trials were made, but no effective lift could be obtained with it. This was attributed to the fact that the wings had been made true planes (flat) instead of being arched underneath as in the first machine.

So a third apparatus was designed and built. The wings were each 12 ft. long by an average width of 6 ft., and were given the cross section and front sinuosity of those of a soaring vulture. They were so built and braced as to allow rotation in a socket at the front of the frame which supported the seat. A hinged tail was added, as in the two previous trials, and the machine weighed 50 lbs.

This last apparatus proved an entire failure, as no lifting effect could be obtained from the wind, sufficient to carry the 180 lbs. it was designed to bear. Mr. *Montgomery* then turned his attention to other matters, but he has since made a more careful and complete study of the principles involved, and he expects to resume his experiments.

The foregoing pages comprise all the experiments, the result of which has been published, which the writer has been able to collate, and which he has considered of sufficient importance to be described in this account of "Progress in Flying Machines." Other important experiments are pending or in partial progress; but the designers of these have as yet given out no information for publication, and indeed could scarcely do so concerning tentative plans, subject to constant modifications.

The writer has gathered from the newspapers, accounts of some other experiments, but these seem to be so erroneously or vaguely described that no instruction could be obtained by republishing them. It has been the aim of the writer throughout to gather all the information possible, but only to publish that which was reliable and instructive.

CONCLUSION.

Having thus passed in review the various attempts which have hitherto been made to compass artificial flight, there remains the task of pointing out as briefly as possible whether and how the information gathered may be made to conduce to a possible solution of the problem of aviation.

It was thought more effective to bring out the various theories of flight, and my own views, while describing the experiments, rather than to present them in a series of abstract statements and propositions, the immediate bearing of which might not be so evident. The reader has probably reached deductions of his own; but he may also wish to know my own general conclusions, and in what manner if any the many failures which I have described can be made to subserve eventual success.

These failures have resulted from so many different causes that it is evident that many conditions must be observed. These conditions virtually each constitute a separate problem, which can probably be solved in more ways than one, and these various solutions must then be harmoniously combined in a design which shall deal with the general problem as a whole. These various conditions, or problems, as I prefer to call them, may be enumerated as follows:

1. The resistance and supporting power of air.
2. The motor, its character and its energy.

3. The instrument for obtaining propulsion.
4. The form and kind of the apparatus.
5. The extent of the sustaining surfaces.
6. The material and texture of the apparatus.
7. The maintenance of the equipoise.
8. The guidance in any desired direction.
9. The starting up under all conditions.
10. The alighting safely anywhere.

Analyzed and viewed in this way, the reader may realize how complicated is the question and how formidable are the various difficulties which are to be surmounted. And yet the scrutiny which has been made of the various experiments attempted and of the progress accomplished in flying machines enables us to perceive that many of these problems have been approximately solved, more particularly since 1889, and that a better understanding of the difficulties to be overcome has been obtained concerning several others.

1. The first problem to be considered is that pertaining to the resistance and supporting power of air. By the use of currently accepted formulæ it could not be figured out a few years ago how birds were supported in flight. Now that Professor *Langley's* experiments have confirmed many of those previously tried, we are enabled to say that the empirical formula of *Duchemin* (from which the table of "lift" and "drift" herein given was calculated) is approximately correct, and to figure out the support and the resistance with some confidence of not going far wrong.

These calculations seem to indicate that artificial flight is possible, even with planes; that very flat angles of incidence, from 2° to 5°, hitherto considered inadmissible, will be the most advantageous, and that within certain limits of hull resistance high speeds will require less power than low speeds, because they admit of obtaining support from the air at a flatter angle.

We have seen that the "drift" diminishes as the angle of incidence becomes less, that the "hull resistance" (including car, framing, braces, etc.) increases as the square of the speed, and that the skin friction is so small that it may for the present be disregarded, and we are enabled to calculate, approximately at least, the power required to obtain support in flight with planes, and to overcome the resistance, although we are not yet aware what limit will be imposed upon the size of artificial apparatus by the law that the weight will increase as the cube, while the sustaining surfaces will grow only as the square of the similar dimensions.

Moreover, the formulæ which give this promise of success were derived from experiments with plane surfaces, and we already know that concavo-convex surfaces will be still more effective, although the most favorable shapes are not yet ascertained. This statement indicates the direction in which scientific investigation and experiment should now proceed, and holds out the hope that this first problem is in a fair way of being solved.

2. The second problem—that concerning the motor to be employed—has justly been considered to be the most important and difficult of solution. It seemed hopeless to rival, with an artificial motor, the output of energy appertaining to the motor muscles of birds in proportion to their weight, which, as we have seen, there is good reason to believe develop work in ordinary flight at the rate of 1 H.P. to 20 lbs. of weight, and can for a brief period, in rising, give out energy at such rate as to represent an engine of only 5 or 6 lbs. of weight developing 1 H.P.

The writer has, on a former occasion,* passed in review the comparative weights of various classes of engines. He found that the lightest engines in use in 1890, including the generator of power, weighed 60 lbs. per H.P. for steam, 88 lbs. per H P. for gas engines, and 130 lbs. per H.P. for electric motors. He intended to discuss the subject further in this account of "Progress in Flying Machines," but recent achievements with steam engines seem to make this unnecessary. Marine (yacht) engines have been reduced more than one half in weight; Mr. *Hargrave* has produced a steam engine weighing 10.7 lbs. per H.P.; M. *Maxim* has created one weighing but 8 lbs. per H.P., including a condenser, and other experimenters are approximating closely to the same weights

Steam engines, therefore, seem to have been so much reduced in weight as to admit of their being employed as motors for flying machines. This may not be a final solution, for it may be that some form of gas or petroleum engine will prove to be still better adapted to aerial purposes, as indeed has been already hinted by M. *Maxim;* but in any event, his steam engine seems to be light enough to make a beginning of artificial flight, if the other problems pertaining thereto can also be solved.

* Aerial Navigation. A lecture to the students of Sibley College, 1890.

But it is possible to utilize a still lighter power, for we have seen that the wind may be availed of under favorable circumstances, and that it will furnish an extraneous motor which costs nothing and imposes no weight upon the apparatus.

Just how much power can be thus utilized cannot well be told in advance of experiment; but we have calculated that under certain supposed conditions it may be as much as some 6 H.P. for an aeroplane with 1,000 sq. ft. of sustaining surface; and we have also seen that while but few experimenters have resorted to the wind as a motor, those few have accomplished remarkable results.

3. As regards the selection of the instrument through which propulsion is to be obtained, we have seen that experiment has shown that reaction jets, whether obtained from explosives, steam, or blasts of air; that wave action; that valvular, folding or feathering paddles or vanes have all proved inferior in practical application to screw propellers or to propelling wings, and that the two latter (if we are to judge from Mr. *Hargrave's* experiments) are about equally effective. It being understood, however, that this statement refers to wings only as propelling instruments and not as sustaining surfaces. We may conclude, therefore, that the third problem may now be solved either with screws or with waving wings, as best conforms to the rest of the design.

4. This brings us, therefore, to consider the solution of the fourth and important problem of what kind or form of apparatus should be selected for sustaining the weight—whether flapping wings, screws or aeroplanes. The best measure of comparison will be the weights or number of pounds which experiment shows may be sustained per H.P. with each form, considered in connection with the weight of the construction required to make that form abundantly strong against the resulting strains. The difference between the two weights will indicate the proportion of the whole which may be devoted to the motor. It is desirable, therefore, to consider each form or kind of apparatus separately.

We do not yet know accurately how many pounds per H.P. can be sustained in horizontal flight with a bird-like apparatus of flapping wings. The toy birds which have been described support only from 6 to 20 lbs. per H.P., but this inefficiency is largely due to the undue friction of the working parts and to the abnormal head resistance of the framing in such imperfect models. The writer has estimated that in the case of a flying pigeon about 77 lbs. are sustained per H.P., but as this is partly based on conjecture, it may be an underestimate.*

Upon the whole, the writer is inclined to admit that about 100 lbs. per H.P. may be sustained with flapping wings, this including the power required both to support the weight and to overcome the head resistance. He believes, moreover, that in an artificial machine of sufficient size to sustain one man, the strength required to resist the constant reversals of strains due to the alternating motion of the wings will involve such dimensions that the weight of the apparatus and man will amount to at least ⅘ of the whole, thus leaving but ⅕ of the total weight which can be devoted to the motor and its adjuncts, including the fuel and supplies for the journey.

Concerning aerial screws we have abundant experimental data. *Nadar*, *Wenham* and *Freninges* each obtained a sustaining effect of 33 lbs. per H.P.; *Dieuide* realized 26.4 lbs., and *Dahlstrom* and *Lohman* secured 87.6 and 55 lbs. per H.P., while *Renard* obtained from 17 to 48 lbs. thrust by screws rotating at various speeds, and *Moy* recorded 40 lbs. per H.P. sustained from a wind wheel with vanes of variable pitch.

These performances, however, included a certain amount of ascension, which absorbed part of the power, so that probably we shall be quite safe in assuming that in mere horizontal flight some 45 lbs. per H.P. can be sustained with screws.

As the strains in a rotating apparatus will be less destructive than those involving reversals of motion, it seems probable that screws may be constructed with a less weight of materials than flapping wings of the same sustaining power. It is judged that an apparatus can be constructed to sustain the weight of one man with rotating screws, in which only about ¾ of the weight shall be absorbed by the framing, screws, car and man, thus leaving ¼ of the whole weight for the motor and its various adjuncts. The practical result of this estimate will be elicited further on.

We have also a number of experimental data concerning aeroplanes. Professor *Langley* sustained a maximum of 209 lbs. per H.P. with planes at an angle of incidence of 2°, and M. *Maxim* sustained 133 lbs. per H.P. at an inclination of 1 in 14. These data apply to the plane only. Neither of these per-

* M. *Lilienthal* raised 93 lbs. per H.P. in his experiments, but this was counterbalanced weight, and there was no head resistance of forward flight to be overcome.

formances included the head resistance due to the framing and car which are indispensable in an actual machine, so that we must derive our premises from complete models. With one of the latter *Tatin* sustained 110 lbs.; *Phillips*, 72 lbs., and *Hargrave*, 89 lbs., 76 lbs., and 79 lbs. per H.P. in horizontal flight. We may safely conclude, therefore, that 100 lbs. per H.P. can be sustained in horizontal flight with an aeroplane.

As the latter consists of fixed surfaces receiving no strains save the sustaining pressure of the air, it is believed that such class of apparatus can be constructed of sufficient size to sustain one man, so that about one half of the whole weight shall be devoted to the apparatus and man, and the other half to the motor and its adjuncts.

These estimates of the proportion of the sustained total weight which can be spared for the motor, are necessarily mere estimates made in advance of actual testing, and (for reasons to be stated hereafter) upon the smallest size of apparatus practicable for actual man-flight, yet they enable a comparison to be made between the various forms of apparatus which have been herein described. The result is as follows :

COMPARATIVE EFFICIENCY OF VARIOUS FORMS.

Kind of Apparatus.	Pounds sustained per H.P.	Proportion available for motor.	Resulting possible weight of motor per H.P.
Screws....................	45	⅓	15 lbs.
Wings....................	100	¼	25 "
Aeroplanes...............	100	½	50 "

The above table, based as it is upon experimental data of weights actually sustained, indicates that aeroplanes are probably the best forms to experiment with, because they admit of a larger proportion of the whole weight being appropriated to the motor. It also indicates the possibility of success in artificial flight, with motors weighing 10 or 15 lbs. per H.P., provided that the remaining problems be also solved ; but it must not be overlooked that more power will be required in rising from the ground than in horizontal flight, and that the actual proportion of the total weight available for the motor, although conservatively estimated from the best data available,* is still a matter to be proved by experiment.

The common basis which has been here selected for comparison is that size of apparatus sufficient to support the weight of one man. This is the smallest which can be adopted, and it is theoretically the most favorable, for inasmuch as the weight of the framing will presumably increase as the cube of the dimensions, while the sustaining surfaces will increase as the square of these same dimensions, it is seen that the ratio of the total weight sustained which can be spared for the motor will not be constant, but that the larger the apparatus the more it will weigh in proportion to its surface and the less there will remain for the engine and its adjuncts. Flying machines, therefore, should preferably be designed as small as practicable, and experimenters will place themselves at a disadvantage if they construct large machines.

5. As regards the fifth problem—the amount of the sustaining surface required—it depends on the speed, and it is probable that, within certain limits, no particular extent (in ratio to the weight) can be said to be absolutely the best, because a large part of the resistance will consist in the "drift," and the latter is independent of the area of the sustaining surface ; a small area at high speed being able to sustain as much weight as a larger area at a corresponding lesser speed, as indeed is indicated by the formula already given for the drift : $R = W$ $tang. @$, in which the element of surface disappears.

Practically, however, the weight of the necessary framing and the hull resistance will determine the ratio of surface to weight which will be most advantageous. We have seen that encouraging experiments have been made with surfaces varying from 0.75 sq. ft. per pound in the case of Herr *Lilienthal* to 7 sq. ft. per pound in the case of M. *Hargrave*. It seems probable that the latter is in excess, and that it would be preferable to confine the dimensions of artificial machines within the proportions which obtain with fast-flying birds, as shown in the table heretofore given, this being from 3.62 sq. ft. per pound in the case of the swallow, to 0.44 sq. ft. per pound in the case of the male duck, with which areas, if we consider their wings as planes, and the angle of incidence to be 3°, the swallow requires a speed of 28.1 miles per hour and the duck a velocity of 66.2 miles per hour to sustain their weight.

* *Maxim's* aeroplane and the soaring devices of *Le Bris*, *Mouillard*, *Lilienthal*, and *Montgomery*.

To come down safely, at the speed of the parachute, requires about the ratio of the swallow, while the proportions of the duck are more favorable to high speed. As the drift will increase only if the angle of incidence be increased, it would seem preferable to maintain this angle as uniform as possible, and to provide variable supporting surfaces to be folded or unfolded with variations of speed, if such a construction can be devised in connection with the concavo-convex surfaces which have already been mentioned as likely to give the most satisfactory results.

6. The sixth problem cannot be said to be solved, for there is considerable uncertainty concerning the best materials to be employed for the framing and for the moving parts ; or what should be the texture of the sustaining surfaces in an actual flying machine. Hitherto the main question has been to construct a model which would fly at all ; and experiments with models have not thrown much light on the question of materials. If a partial success be realized, this problem will assume greater importance.

It involves considering materials from a somewhat new point of view, or investigating their strength and stiffness per unit of weight, so as to secure a maximum of resistance with a minimum of weight. The quill of a bird's feather is stronger and more elastic than an equal weight of steel, and the texture of its barb is peculiar.

It now seems probable that bamboo, the lighter of the stiff woods, and some varieties of steel, will be found to be the preferable materials for the framing. Contrary to popular belief, aluminium is inferior to steel per unit of weight, particularly in compression, but it does not corrode and may be preferable on that account. It may be utilized for the sustaining surfaces, either as thin sheets or as wire gauze made smooth by some coating ; but textile fabrics will probably be the first to be employed for full-sized apparatus. One important requirement, however, is that the surfaces shall not unduly change their shape under varying air pressures. They must be rigid, and, perhaps, elastic, and the fluttering of textile fabrics is likely to give trouble to experimenters. It may be, therefore, that thin wood, parchment, or pasteboard may prove preferable, the latter being corrugated lengthwise of the direction of motion in order to gain stiffness.

The barb of a feather is smooth in one direction and asperous in the other ; and it is possible that a similar texture of surface may prove of advantage in flying machines, but this probably will not be determined until partial success has been achieved with an apparatus of sufficient size to sustain the weight of a man.

7. The problem of the maintenance of the equipoise is now, in my judgment, the most important and difficult of those remaining to be solved. It has been seen, from this review of "Progress in Flying Machines," that almost every failure in practical experiments has resulted from lack of equilibrium. This is the first requisite thing to secure, for, as has already been said, safety is the most important element of success—safety in starting up, in sailing, and in coming down.

If a flying machine were only required to sail at one unvarying angle of incidence in calm air, the problem would be much easier of solution. The center of gravity would be so adjusted as to coincide with the center of pressure at the particular angle of flight desired, and the speed would be kept as regular as possible ; but the flying machine, like the bird, must rise and must fall, and it must encounter whirls, eddies, and gusts from the wind. The bird meets these by constantly changing his center of gravity ; he is an acrobat, and balances himself by instinct ; but the problem is very much more difficult for an inanimate machine, and it requires an equipoise—automatic if possible—which shall be more stable than that of the bird.

We have seen from the experiments described that the transverse stability can be procured in two ways : (1) by placing the two halves of the sustaining surfaces at a diedral angle to each other, and (2) by adding a longitudinal keel to the apparatus, as in the case of Mr. *Boynton's* fin kites. The mode of action is practically the same for both, and consists in producing increased air pressure upon the side which tends to dip downward. The two may be employed conjointly, but the keel will produce less head resistance to forward motion than the diedral angle, which resistance, however, may be diminished by turning upward only the outer ends of the sustaining surfaces in a manner similar to the upbending primary feathers of the soaring birds.

Longitudinal stability may be promoted in three ways : (1) By additional surfaces at a slight angle to the main sustaining surface, (2) by placing several surfaces behind each other, (3) by causing the center of gravity always to coincide with the center of pressure. The first way corresponds to the method which has been mentioned as procuring transverse stability by means of surfaces at a diedral angle ; it is illustrated by M.

Maxim's aeroplane, in which two such surfaces are affixed, front and rear; and by M. *Pénaud's* aeroplane, in which but one is affixed in the rear. The second way is illustrated by M. *Brown's* bi-planes and by M. *Hargrave's* cellular kites; and the third is the method universally employed by the birds.

For an artificial machine this last method is as yet an unsolved problem. Several inventors have proposed methods of shifting weights to change the position of the center of gravity as the apparatus changes its angle of incidence, but none of these are automatic, and none have been tested practically.

8. The guidance in a vertical direction—*i.e.*, up or down, depends in a great degree upon success in the changing the center of gravity which has just been alluded to. It may be partly effected by changes in the speed or by horizontal rudders, but in such case the equipoise will be disturbed. Guidance in a horizontal direction has been secured, as we have seen in several experiments, by vertical rudders; but there are probably other methods still more effective, although their merits cannot be tested until a practical apparatus is experimented with. Upon the whole, this problem may give trouble, but it does not seem unsolvable.

9. A really adequate practical flying machine will hardly be said to have come into existence until it possesses the power of starting up into the air under all conditions. This problem is as yet unsolved, and may not be until the other problems have been worked out to a success. It is clear that in rising upward more power will be required than in horizontal flight; for to the force required to obtain horizontal support must be added that required to ascend, and the latter will vary with the rapidity of the upward motion. Three principal methods have been experimented with: (1) By acquiring speed and momentum on the ground: (2) by the reaction of rotating screws; (3) by utilizing the force of the wind. The first we have seen to require the use of special appliances, such as railway tracks, so that its application must be limited, and the third necessitates that the wind shall blow, and with sufficient force; either or both may be utilized with the earlier types of practical machines should one or more be hereafter developed; but the writer believes that the second method—that of rising through the reaction of a screw—will eventually supersede the two others. It will involve the difficult design of a simple form of sustaining surfaces which can be alternately rotated as a screw or held as a fixed aeroplane when sailing, the change being effected while under motion in the air.

The writer does not believe that a bird-like machine can rise into the air, under all conditions, by flapping its artificial wings. It would need to be already up some distance to permit such action. Birds spring up three or four times their own height, or run against the wind to acquire speed, and with vigorous flaps of wing they rise at an angle seldom greater than 45°, but their initial action would be quite impracticable to a machine of sufficient size to sustain the weight of a man.

10. The alighting safely anywhere is also an unsolved problem, and one, as will readily be perceived without argument, of vital consequence. It has been slurred over by most of the designers of flying machines, and the best method which has been thus far proposed involves the selection of a smooth, soft piece of ground and the alighting thereon at an acute angle. When it is considered that the speed required for support will be somewhere from 20 to 40 miles an hour, it will be realized that the performance will be somewhat dangerous, and that it would be preferable, if the design of the apparatus will admit of it, to imitate the manœuvre of the bird who stops his headway by opening his wings wide, tilting back his body, and obtaining the utmost possible pressure and retardation from the air before alighting upon the ground. This would require for an artificial machine a rapid change of the center of gravity so as to tilt the apparatus backward to the angle of maximum lift (about 36° by the table) and, immediately thereafter, a counter change of the center of gravity, so as to bring the apparatus back upon an even keel in order to alight at the diminished velocity.

This manœuvre is not as difficult and dangerous as may at first sight appear; but it must be acknowledged that it would be preferable to utilize the reaction of a rotating screw to diminish the forward motion and to hover over the ground before alighting. This involves the same difficult design which has been alluded to as desirable for use in rising, for it does not seem practicable, within the requisite limits of weight, to provide two sets of sustaining surfaces, one set to be used in rising and in alighting, and the other to serve in horizontal flight. These last two problems—the rising and the alighting safely, without special preparation of the ground—seem very difficult of solution, and are probably the last which will be worked out.

(TO BE CONCLUDED.)

ROLLING STOCK STATISTICS.

ROLLING STOCK OWNED BY THE RAILROAD COMPANIES OF THE UNITED STATES IN 1892, AS GIVEN IN THE LAST NUMBER OF "POOR'S MANUAL OF RAILROADS."

Locomotives.	Passenger Cars.	Baggage, Mail and Express Cars.	Freight Cars.	Total Cars.
35,754	[illegible]	7,900	1,168,867	1,203,088

ROLLING STOCK OWNED BY BRITISH RAILROAD COMPANIES ON DECEMBER 31, 1892, AS GIVEN BY A RECENT "PARLIAMENTARY RETURN."

	Locomotives.	Carriages used for the Conveyance of Passengers only.	Other Vehicles attached to Passenger Trains.	Wagons of all kinds, used for the Conveyance of Live Stock, Minerals, or General Merchandise.	Any other Carriages or Wagons used on the Railway, not included in the preceding columns.	Total Number of Vehicles of all descriptions for Conveyance of Passengers, Live Stock, Ballast, etc.
England and Wales ...	14,840*	34,052	12,127	439,109	10,913	496,201
Scotland...	1,880	4,349	1,629	120,580	1,261	127,819
Ireland...	719	1,678	985	15,747	437	18,847
Total...	17,439	40,079	14,741	575,436	12,611	[illegible]

* Including 16 electric locomotives.

THE TORSION VISCOSIMETER.

BY O. S. DOOLITTLE, CHEMIST, PHILADELPHIA & READING RAILROAD.

SEVERAL years ago Mr. S. M. Babcock called our attention in the *Journal of Analytical Chemistry* (Volume I., p. 151) to the use which could be made of the principle of the torsion balance in determining the viscosity of various liquids. The hint which was there dropped in regard to the adaptability of this principle to determining the viscosity of oils has been followed up, and in the torsion viscosimeter as it stands to-day we have but the development of that idea.

The viscosity of an oil is recognized by both the producer and consumer as the most valuable measure of its lubricating power, and yet we find no uniformity whatever in the manner of determining this essential property. There are numerous viscosimeters in use, but no one of them has commended itself to the trade sufficiently to be adopted as a standard.

The essentials of a good viscosimeter are:

1. Accuracy, including both the ability to duplicate results obtained with an oil on the same instrument, and also on different instruments of the same make.

2. Ease and rapidity of cleaning and manipulating, and the reducing of personal error to a minimum.

3. Adaptability of a single instrument to all kinds of oil, at all desirable temperatures.

The great majority of viscosimeters are built on the principle of allowing the oil to flow through an orifice, and counting the number of seconds required for a certain quantity to flow out. Instruments constructed on this plan cannot be made to conform satisfactorily to all the above requirements. As a rule it takes more time to clean and get the viscosimeters of this class ready for a test than for the test itself. If the instrument is made with great care, good duplicate results can be obtained with a perfectly clean oil, but if by any chance a slight particle of dirt gets into the oil, the orifice is liable to become obstructed and the results vitiated.

At the same time these results are but comparative, and poorly comparative at the best, as the head of oil is constantly

changing from the moment the flow begins, and the rapidity of the flow must necessarily depend more or less on the specific gravity of the oil, as we will show later on.

That the personal error is a large one will hardly be disputed by any who have worked with these instruments.

Again you will find, as a rule, several different viscosimeters with varying orifices required for the different oils, a small hole being the best for light oils and a large one for the heavy products.

Having experimented with a number of these viscosimeters in the laboratory of the Philadelphia & Reading Railroad Company, we found them so very unsatisfactory where rapid and accurate work was required, that we abandoned them all and designed an instrument on the above-mentioned principle. In the torsion viscosimeter we have an instrument which, during the year and a half we have had it in daily use, has proved itself reliable, accurate, and satisfactory in every way. It is very easy to clean and manipulate, is adapted to oils of all ranges of viscosity, and reduces personal error to a minimum.

A glance at the cut will show how the principle has been applied. A steel wire is suspended from a firm support and fastened to a stem which passes through a graduated horizontal disk, thus allowing us to measure accurately the torsion of the wire. The disk is adjusted so that the index point reads exactly *O*, thus showing that there is no torsion in the wire. A cylinder 2 in. long by 1¼ in. in diameter, having a slender stem by which to suspend it, is then immersed in the oil and fastened by a thumb-screw to the lower part of the stem of the disk. The oil-cup is surrounded by a bath of water or high fire-test oil, according to the temperature at which it is desired to take the viscosity. This temperature being obtained, while the disk is resting on its supports, the wire is twisted 360° by rotating the milled head at the top. The disk being released, the cylinder rotates in the oil by virtue of the torsion of the wire.

The action now observed is identical with that of the simple pendulum.

If there were no resistance to be overcome, the disk would revolve back to *O*, and the momentum thus acquired would carry it 360° in the opposite direction. What we find is, that the resistance of the oil to the rotation of the cylinder causes the revolution to fall short of 360°, and that the greater the viscosity of the oil the greater will be the resistance, and hence the retardation. We find this retardation to be a very delicate measure of the viscosity of the oil.

There are a number of ways in which this retardation may be read, but the simplest we have found to be directly in the number of degrees retardation between the first and second complete arcs covered by our rotating pendulum. For example, suppose we twist the wire 360° and release the disk so that rotation begins. In order to obtain an absolute reading to start from, which shall be independent of any slight error in adjustment, we ignore the fact that we have started from 360°, and take as our first reading the end of the first swing. Ignore the next reading, which is on the other side of the *O* point, as it belongs in common to both arcs. Take the third reading, which will be at the end of the second complete arc, and on the same side of the *O* point as the first reading. The difference between these two readings will be the number of degrees retardation caused by the viscosity of the oil. Suppose the readings are as follows:

First reading,	right hand	355.6°
Second "	left hand—ignore	
Third "	right hand	338.2°
		17.4° retardation.

In order to secure freedom from error we make two tests: one by rotating the milled head to the right and the other to the left. If the instrument is in exact adjustment, these two results will be the same; but if it is slightly out the mean of the two readings will be the correct reading.

In order to overcome the variations in different instruments, each one is standardized against pure cane-sugar solutions, after the manner proposed by Mr. Babcock, and the viscosity is expressed in the number of grams of pure cane sugar contained in 100 c.c. of the syrup at 60° F., which will give the retardation designated at 80° F. These readings are obtained by making a number of solutions containing known amounts of pure cane sugar, and determining the retardation of each. A curve is then mapped out on a piece of plotting-paper, the number of grams of sugar in 100 c.c. of the different syrups representing the abscissas, and the degrees of retardation, the ordinates. This curve enables us to interpolate the value of each degree of retardation in terms of pure cane sugar, and in this way a table of viscosities is drawn up and furnished with each instrument. This table renders the results obtained by different instruments strictly comparable.

Incidentally while experimenting with these sugar solutions we have been able to show the influence which specific gravity has on the determination of viscosity when made by the class of instruments which allow the liquid to flow through an orifice and express their results in the number of seconds required.

We found the viscosity on the torsion viscosimeter of a certain oil having a sp. gr. of 0.9 to be 86.4. We then made a sugar solution showing exactly the same viscosity, and found its sp. gr. to be 1.4. These two liquids having identically the same viscosity as shown by the torsion instrument, but differing in specific gravity, were then run through the Saybolt viscosimeter. The oil required 35¼ seconds, while the sugar solution ran through in 30¼ seconds, thus showing that the difference in specific gravity caused an error of 5 seconds on this instrument by forcing the sugar solution through the orifice faster than the oil. To demonstrate still further the presence of this error due to specific gravity, we ascertained the viscosity of an oil having a sp. gr. of 0.9 to be 35¾ seconds on the Saybolt instrument. We then made a sugar solution which gave the same figure on this viscosimeter, showing a sp. gr. of 1.48. The viscosity of these two liquids was then taken on the torsion viscosimeter, when it was found that the oil showed a viscosity of 86.8, while the sugar solution gave 91.8. In other words, it was necessary to make a solution of sugar of decidedly higher actual viscosity than the oil, in order to overcome the error due to difference in specific gravity and show the same reading on the Saybolt viscosimeter.

From this it would seem clearly evident that the viscosity as determined by any instrument based on the principle of allowing the liquid to flow from a receptacle through an orifice, has a very appreciable error due to the specific gravity of the liquid.

The torsion viscosimeter is free from this objection and many others which belong to this class of instruments. It is applicable to all grades of oil, regardless of their character or fluidity, being independent of the gravity and of any reasonable amount of dirt the oil may contain. The viscosity of an oil can be taken at any temperature as many times as may be desired without any inconvenience from being obliged to handle the hot oil. This we think is an important point, as the practice in common use of determining the viscosity of cylinder stock at 212° F. does not tell us what we want to know. We should know the viscosity of an oil at the temperature at which it is to be used, which in the case of cylinder stock is in the vicinity of 350° F. We have repeatedly found oils tested at 212° simply reversing their comparative values when heated to 350°. We need an instrument with which the viscosity can readily be determined at a high temperature with a minimum amount of trouble. By means of a paraffine or high fire-test oil bath for our oil-cup, we have no trouble whatever in doing this with the torsion viscosimeter.

The necessity of a standard instrument which shall be recognized as such by the trade cannot be too forcibly emphasized, as the present state of affairs is very annoying to both the producer and consumer, leading, as it so often does, to misunderstanding and financial loss. The torsion viscosimeter is manufactured by Bullock & Crenshaw, Philadelphia, Pa.

A PROPOSED UNIFORM SYSTEM OF SCREW-THREADS FOR FRANCE.

In France there is no standard system of screw-threads adopted in engineering construction, but the greatest diversity exists between the threads of screws having the same diameter.

In the large military, naval, and railway workshops special systems have been adopted, which, however, differ one from the other, so that it is very rare to find two screws of the same diameter (taken at random) having the same pitch and form of thread. A commission was appointed by the society to consider the best means of arriving at a uniform system of screw-threads.

The report contains details of the various systems of screw-threads in use—Whitworth, Sellers, and eight special systems used in France, as well as some systems that have been from time to time proposed as standards.

In a form of screw-thread recommended for adoption as standard, ease of manufacture is of great importance. The form recommended has as its basis an equilateral triangle, whose side is equal to the pitch, one-eighth part of the height of the triangle being cut off at top and bottom, parallel to the axis of the screw. There are 20 principal sizes of screws, denoted by the numbers, 0, 1, 2, 3, . . . 19.

The pitch of the screw, p, the diameter of the screw, D, and the width of the nut across the flats l in millimeters are given by the formulas :

$$p = \frac{n}{2} + 1$$

$$D = \frac{(n + 10)^2}{5} - 14$$

$$l = 3\,n + 5 + D.$$

The following table gives the sizes of the principal screws ; the number 0 (corresponding to $D = 6$ mm.), the inferior limit of the series, being the same as the superior limit in the Thury standard system in general use for watch and clock screws.

If a screw of intermediate diameter is required, it should be expressed in millimeters by a whole number, and the pitch taken the same as that of the principal screw of immediately smaller diameter.

n.	*p.*		*D.*		*l.*	
	Mm.	Ins.	Mm.	Ins.	Mm.	Ins.
0	1.0	0.04	[illegible]	0.24	10	0.39
1	1.5	0.06	10	[illegible]	[illegible]	0.79
2	2.0	[illegible]	15	0.59	[illegible]	[illegible]
[illegible]	2.5	0.10	20	0.79	[illegible]	1.37
[illegible]	3.0	0.12	[illegible]	0.98	[illegible]	1.58
5	3.5	0.14	[illegible]	1.22	[illegible]	1.97
6	4.0	0.16	37	1.46	[illegible]	2.36
7	4.5	0.18	44	1.73	70	2.76
8	5.0	0.20	51	2.01	80	3.15
9	5.5	0.22	[illegible]	[illegible]	90	3.54
10	6.0	0.24	[illegible]	2.60	100	3.94
11	6.5	[illegible]	74	2.91	110	4.33
12	7.0	[illegible]	[illegible]	3.27	125	4.92
13	7.5	[illegible]	[illegible]	[illegible]	135	5.31
14	8.0	0.31	101	[illegible]	150	5.90
15	8.5	0.33	111	4.37	160	6.30
[illegible]	9.0	[illegible]	121	4.76	175	[illegible]
17	9.5	0.37	132	[illegible]	[illegible]	7.48
18	10.0	[illegible]	143	[illegible]	[illegible]	7.88
19	10.5	0.41	154	[illegible]	215	8.46

A memoir by Mr. Marre, of the firm Bariquand & Marre, on the " Manufacture of Triangular Screw-Threads" is appended to the report. A tool and holder is described, the arrangement being such that the form of the thread produced is not altered by grinding the tool.

A note on the unification of screw-gauges is appended. This note gives tables of the principal gauges used in England, America and France.

The commission recommend that 5,000 copies of their report be distributed among persons interested in the subject—engineers of the State technical societies, railway and shipping companies, etc.—with a view to elicit a general discussion and prepare the way for the adoption of a uniform system.—*Bulletin de la Société d'Encouragement pour l'Industrie Nationale.*

THE GOVERNMENT NEW LOCATION FOR THE RAILROAD ACROSS THE MAIN CAUCASUS RANGE.

By A. Zdziarski, C.E.

The Transcaucasian Railroad, finished in 1881, and connecting the two ports of the Black Sea—Poti and Batoum—with the Bakou and its oil (petroleum) region on the Caspian Sea, serves the local traffic of the Transcaucasian country and the transit between Europe and Persia, but is quite separated from the railroad system of the Russian Empire.

The great Caucasus range, in its whole length from the Black to the Caspian Sea, is an impassable impediment for any communication between the Russian Empire and the Transcaucasus. Therefore soon after the conquest of that country the Russian Government had in view the necessity of creating a communication, and the result of that has been the construction of the Military Grouzin Highway (Chaussée), the single continental road which now connects the Russian Empire with the Transcaucasus.

Of course one road (Chaussée) could not long satisfy the increasing requirements of communication and traffic ; and in 1873 Mr. Statkowski, C.E., was commissioned to execute the surveys and location of a railroad across the great Caucasian range in order to connect the Northern Caucasus with the Transcaucasus.

The line of first location was laid along the Military Grouzin Road—it is along the two principal rivers flowing from the summit of the range, the Terek, on the northern slope, and the Great or White Aragva, on the southern slope, and provided for a tunnel under the Krestovsk Pass. A variation of line was located along the Tsno River, a tributary of the Terek, and Black Aragva, a tributary of the Great Aragva, but did not present any important advantages. These lines are indicated on the map by " L., 1873."

In the year 1875 Mr. Statkowski made new surveys and located a new line between Gori, on the Transcaucasian Railroad, and Dar-kokh, on the Vladikavkaz Railroad, along the valleys of Lakhva and Ardon rivers, through the Djomag, or Mag, Pass. This location was found more easy and economical than the previous one, and is designated " Loc., 1875" on the map.

Another proposition was made by the Vladikavkaz Railroad Company to construct a long loop line *via* Petrovsk and Bakou ; but this line would increase the distance between the empire and the center of Transcaucasus about 1,000 versts (666 miles), and, however profitable for local traffic, could not be considered as a main line.

In 1890 the question of a railroad through the Caucasus range came up again, and the committee of ministers decided to order surveys and final location of this line, Mr. Rydzewski, C.E., being appointed as a Chief Engineer.

PRELIMINARY RECONNOISSANCES.

The railroad to be located was intended to connect the Vladikavkaz Railroad and the Transcaucasian Railroad, and therefore it must pass across the central part of the range. There are here the five following passes (going from the west) : (1) Mamison, 9,390 ft. high on sea level, and dividing the sources of the Rion and Ardon ; (2) the Djomag (or Mag) Pass, 9,842 ft. high, dividing the sources of the Lakhva and Ardon ; (3) the Krestovsk, 7,977 ft. high, dividing the sources of Great Aragva and Terek ; (4) the Bouslachirsk, 8,088 ft. high, dividing the sources of Black Aragva and Tsno, and (5) the Arkhot, 9,700 ft. high, dividing the sources of Khevsara-Aragva and Assa.

From these five passes, the first (Mamison) was found to be situated too far to the westward ; the three following were explored by Mr. Statkovski, and only one of them—the Djomag Pass—was found suitable ; the last pass (Arkhot) has been explored and surveyed since then.

Before describing the results of surveys, some general observations on the location of mountain railways will be of some interest.

There are two systems of locating a railway in a mountainous country with one or more expected tunnels—viz., the *high* location and the *low* location. In the high location the line begins to rise from the middle of the valley, where the slope of the valley is less than the maximum slope of grading, so that, by rising with the maximum slope of grading, the line in the upper end of the valley reaches the appointed entrance to the main tunnel. In the low location the line is laid as low as possible, and in the upper end of the valley, in order to keep the maximum slope and reach the tunnel entrance, the line must be lengthened by means of going in lateral valleys and by means of spiral tunnels.

When the construction of long tunnels was still very difficult, the high location prevailed. The Semmering Railroad and Brenner Railroad were constructed in this way. But when the construction of the Mont Cenis Tunnel developed the new improvements in tunnel construction, then the low location, being more economical, began to be applied, and the St. Gothard Railroad and the Arlberg Railroad were built in that way.

The chief advantages of low location are the following : It is more easy for construction and operation, going near to the bottom of the valley ; the crossing of lateral valleys is more light, and the crossing of the main valleys is also quite possi-

ble ; there are fewer snow avalanches to be met ; the construction and the carrying of materials is lighter ; the permanent bridges are cheaper.*

The greatest height at which the operating of the railroad is possible in the Caucasus Mountains, according to the scanty meteorological observations and the opinion of General Chodzko, was adopted –4,500–5,000 ft. It is not a great deal higher than in the Alpian country, where the highest point of railroads are : St. Gothard Railroad, 3,758 ft. ; Arlberg Railroad, 4,299 ft. ; and Brenner Railroad, 4,485 ft.

The minimum height at which the tunnel can be projected depends upon the distribution of the temperature in the range. This temperature increases going inside, and at the level of the tunnel it will be no more than + 35° C. ; the working at a higher temperature being impossible without artificial cooling of air, and this is very costly. The value of one geothermical grade (the depth at which the temperatures increases 1° C.) was computed from the practice of the Souram Tunnel, where the mean temperature was 15 – 16°. As the height of range over the tunnel was 366.39 meters, the mean yearly temperature + 8°, therefore the geothermical grade $= \frac{366.39 - 8.53}{16 - 8} = 44.73$. (Here 8.53 is the depth of the layer under which the temperature is constant.) The height of Arkhot Pass is 9,700 ft. = 2,956 m., the mean temperature + 3° ; therefore the depression of the tunnel above the pass can be (35° – 3°) 44.73 = 1,431 m., and the minimum height of the tunnel 2,956 – 1,431 = 1,525 m. = 5,003 ft. The same result can be verified by the formula of Stampf, from the data of St. Gothard Tunnel. According to this formula, the temperature in the tunnel t is

$$t = \sqrt[4]{41.6593 - 0.1517\,h + 0.0001195\,h^2 + 6.45} + 0.0106\,h \pm 2.5\,;$$

and supposing the depth $h = 1{,}431$, we have $t = 27.44°$ to 32.44°, and with the mean temperature + 3°, we have the temperature at a depth of $1{,}431 = T = 30.44°$ to 35.44° C., it is the same as before.

According to these results, the most suitable height of the entrance in the main tunnel was adopted as being from 4,700 to 5,000 ft.

Great difficulties in construction of approaches have been presented by the weakness of rocks forming the slopes of mountains, the snow avalanches and the great rains.

The slopes of mountains chiefly consist of argillaceous slate, very weak and undurable. It was decided to restrain the superficial sliding by means of retaining walls, or to go over them by means of bridges.

The snow avalanches are here not so great as in the neighboring valleys of Terek, Ardon, and White Aragva, which cross the higher point of the range and are near the glaciers, covering the summits of it. Many avalanches can be directed under the bridges ; other avalanches can be avoided by laying the line in tunnels or carrying them on the other side of the valley.

The mountain rains are here also not so strong as in the valleys of Terek, Ardon and Lakhva, the latter being also fed by the waters of glaciers, snow and ice. In consequence of the above, a special reconnoissance along the Arkhot line was made in the summer of 1891.

The reconnoissance of the Arkhot line was based on the maps of general staff survey (ordnance survey) ; the heights of the principal valleys were measured by means of barometers of Fortin and of Parrot, and the heights of secondary valleys by means of aneroids of Naudet and Goldschmidt. The geological explorations have also been made. This reconnoissance has shown that on both the slopes of the range (northern and southern) the valleys are so wide and their slope is so small that the location of a *low* line presents no difficulties. But for the comparison, on the divide section one high line and two low lines were located—the high line, with a tunnel 3 miles long at a height of 6,300 ft. ; the low line, with a tunnel 7.3 miles long, the height of the north entrance being 4,935 ft., and that of the south 5,180 ft., and another low line with a tunnel 10 miles long, the heights of entrances being 4,935 north and 4,536 south. The comparison of these three locations has shown that the high location required a line 15¼ miles longer than the first low location, and 18 miles longer than the second ; the maximum grade being 2.4 per cent.

In the two low locations the great slope of the upper parts of valleys required a lengthening of line on the northern side 6,125 ft. and on the southern 16,431 ft. and 5,600 ft., which can be made only by means of spiral tunnels.

Besides the crossing of the main range a secondary range—the divide between Terek and Assa—had to be crossed. From the three proposed and explored lines, that going over Tarska was adopted as the best, although it requires the construction of a tunnel about 4 miles long.

According to this reconnoissance, the length of the line with 7½ miles of tunnel was fixed at 159 v. = 106 miles.*

Now these results must be compared with the line designed through the Djomag Pass. But as this line was located high, therefore, for the sake of comparison, its location was changed to a low one. It has required a special reconnoissance of that line.

The comparison of the two locations—one desired through Arkhot Pass, another through Djomag Pass—is shown in the following table :

	Arkhot line, with 7½ mile tunnel.	Djomag line.
General length of line to be constructed	106 miles.	122 miles.
Distance from Tyflis to Dark-kokh.	131 miles.	169 miles.
Greatest height	5,302 ft.	6,065 ft.
Glacier	None.	Very near.
Cost of construction (approximate).	44,860,000 to 50,898,000 roubles.	48,754,000 roubles.

As the advantages of the Arkhot line are obvious, therefore it was decided to lay the location along the same.

THE LOCATION.

For exploration and survey the whole line was divided into three sections—one mountain or divide section and two level or plane sections, the northern and southern.

The technical conditions of designing given by the government have been the following :

For the mountain section, the minimum radius of curvature 700 ft., and the limiting grades (1) in the open parts and straight lines, 2.8 per cent. ; on limiting curves, 2.5 per cent. ; (2) in small tunnels (less than one-third of a mile), in straights, 2.69 per cent. ; on limiting curves, 2.4 per cent. ; in tunnels one-third of a mile long, in straights, 2.35 per cent. ; on limiting curves, 2.1 per cent ; (3) in the main tunnel on straight line, 1.55 per cent.

For the level sections, the minimum radius of curvature 875 ft., and the limiting grades (1) on straight lines, 1.5 per cent., and on limiting curves, 1.25 per cent. ; (2) in small tunnels one-third of a mile long, in straight lines, 1.16 per cent., and on limiting curves, 0.97 per cent.

The final location was laid in the following manner : Firstly, an exact topographic survey of the country along the general direction of the line was made. It consisted in running a main line (given by previous reconnoissance), which was carefully measured and leveled, and taking from the stations of that main line as many points in the neighboring valley and mountains as necessary. The position, distance, and height of these points were measured by means of the tachometer of Moineau, made by Kern, in Switzerland. By this means a map with contour lines was made in a scale of $\frac{1}{1000}$. Besides these the survey of both tunnels was made by means of triangulation.

The topographic map of the country being ready, the line of the railroad was laid down, then again leveled, amended when necessary, and then finally located.

The final location has shown that the proposed low line with 10 miles of tunnel was not feasible, because of a fault in the military maps † serving for the preliminary location.

All the data necessary for determination of bridge openings were also collected. In European Russia, as in almost the whole of Europe, the quantity of water flowing from a small watershed is reckoned by the known formula of Köstlin (in meters) :

$$W = 0.000016\ Q\ L \text{ cubic meters,}$$

where Q is the area of watershed in square meters, and L a coefficient, depending on the length of the watershed—viz. :

For length under	3½	kilometers	$L = \frac{1}{2}$
" "	3½ – 7	"	" $= \frac{1}{2} - \frac{1}{3}$
" "	7 – 10½	"	" $= \frac{5}{16}$
" "	10½ – 14	"	" $= \frac{1}{4}$
" "	14 – 17½	"	" $= \frac{3}{16}$.

For the slopes less than 0.005, the coefficient L can be made ½.

This formula is based on the supposition that the greatest European rain gives 57 mm. of water in an hour. But in the

* The last condition has no importance in the construction of many American railroads, where the temporary trestling takes the place of permanent bridges, and temporary slopes, with safety switches, are allowed, and snowsheds are in use. Such a system of construction can be sometimes cheaper, when applying the high location.

* In the final location the length became greater (112 miles), because of a fault in one height taken from the military map, the position of south entrance being shown about 370 ft. lower than it is in reality.

† The south entrance point was shown about 370 ft. lower than it really is.

Caucasus Mountains (southern slope, 4,000 ft. high) rain has been observed which gave 26.6 mm. in 15 minutes, say 86.4 mm. in an hour. Therefore the results of Köstlin's formula have been increased by 50 per cent.

(TO BE CONTINUED.)

EVOLUTION OF THE ATLANTIC GREYHOUND.*

By Charles H. Cramp, Esq., Vice-President.

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Four hundred years is not a very long time when measured as part of the total sea-faring history, but it is enough to have witnessed a progress in the means of transatlantic travel from the caravels of Columbus to such giant steamships as the *Lucania*, *Paris*, *Teutonic*, and their coadjutors or competitors. To trace the history of transatlantic travel, from Columbus crawling across an unknown sea in a clumsy craft that would not now be "rated" in any shipping list, to the captains who drive the great steam liners with almost the regularity of limited express trains, would be or could be made, perhaps, the most entertaining theme possible to a modern pen; but manifestly its natural and necessary scope would far transcend the limits of a paper like this.

Recent events have directed public attention in the United States toward the subject above suggested with a degree of national interest hitherto unfelt during the last 20 years.

From the beginning of the seventies—say, 1871-72 to the present time—the American people have, seemingly, been content to employ Englishmen, Frenchmen, and Germans as the common carriers of the ocean traffic. It is not the purpose of this paper to discuss the causes of this state of things. In fact, no profitable information could be evolved by such discussion, and perhaps the only effect would be to revive conflicts of policy and opinion which, having raged in our public prints and in the halls of Congress for more than a decade, have now, to all appearances, ceased, pending a trial in good faith of measures adopted by the Fifty-first Congress and, by acquiescence at least, sanctioned by the Fifty-second.

At all events, such is the view of the case taken by the commercial public, so that now, for the first time in 20 years, domestic capital and enterprise are beginning to look to the ocean for a field of operations, and to steamships as an object for investment.

In view of these facts, and for other reasons which need not be stated, I shall limit the scope of this paper to the last 20 years, as marking the era intervening between the practical abandonment of ocean traffic by our people and the beginning of their efforts to resume it.

While sea routes are almost numberless, and many of them of vast importance in the sum total of the world's commerce, that of the North Atlantic, embracing the grand thoroughfare of trade and travel between the great powers of Europe and the northern half of the Western Hemisphere, well-nigh overshadows all the rest combined in value and volume of its transactions, and totally eclipses them in the character of its vehicles. To such an extent is this true that, of all the myriad of steamships afloat, not more than 20 or 30 are popularly known even by name, and these are the great vessels which, under the popular designation of "Atlantic Greyhounds," ply in passenger and express traffic between the United States and the principal nations of Western Europe. Plying on the thoroughfare of chief intercourse between civilized nations, they come and go, constantly fraught with the utmost valuable lives in both hemispheres, and for that reason, if for no other, their every performance is eagerly watched by the universal public until their names and the lines to which they belong have become household words.

During the period under discussion—say, from 1871 to the present time—the prime effort of these transatlantic competitors has been to reduce time required in passage, and while of course other qualities—seaworthiness, comfort, and luxury of appointments—have held an even pace in the general contest for supremacy, the effort to augment speed has been so marked and so persistent as to create the aspect of a perpetual race, in which the development of the steamship has become an object enlisting the art and skill of the most masterful minds, and where each successive "lowering of the record" marks a triumph for designer and builder, a fame world-wide and substantial in benefit to mankind.

Under these circumstances it is not too much to say that the grand contest for supremacy on the international race-course of the North Atlantic has ennobled the vocation of those who plan ships and build them, and those who manage them to a grade which abates none of its pride by comparison with any other field in which the human intellect has ever held sway.

While it is true that quick passages and regular runs were always desiderata, even in the days of the old sailing packets, and in the early and primitive stage of the steam epoch, no considerable sacrifices of capital and no especial exertion of skill were then offered to secure those objects; as, indeed, the first thought in these times was to get across without shipwreck, and the question of a few days more or less of passage time was reckoned only as of incidental value.

It is sufficient for the general purposes of historical accuracy to say that the first real "send off" in the great modern steamship race was given by the Inman Company in 1869-70 with the *City of Brussels*, which "broke the record" up to that time by a passage of 7 days, 22 hours, and 3 minutes, being the first to get within the 8-day limit; the best record up to that time being that of the old *City of Paris*—8 days, 4 hours, and 1 minute, in November, 1867. The *City of Brussels* was regarded as a culmination of the shipbuilder's art only 23 years ago, but supervening progress has left her so far in the rear that she is hardly worth description now, except to indicate the starting-point of the advancement, the results of which we see in the colossal flyers of to-day. She was 390 ft. long between perpendiculars, 40 ft. 4 in. beam, and registered 3,090 tons gross; her displacement at 26 ft. draft being 6,900 tons. Her engines were simple, direct-acting, with two 90-in. cylinders of 54-in. stroke, and with steam at 30 lbs. she developed 3,020 indicated H.P. and realized an average speed of 14.53 knots in her best trip. To this challenge of the Inman Line the White Star people quickly responded with the *Oceanic*. This was a vessel of 3,808 tons gross, British Admiralty measurement; 420 ft. long, 40.9 ft. beam, with a depth for tonnage of 23.4 ft. She was powered with a pair of compound or double-expansion engines, having four cylinders; two high pressures of 29 and two low pressures of 78 in. diameter on the "tandem" plan, with a 60-in. piston stroke, and carried usually 66 lbs. of steam. The distinguishing feature of the *Oceanic* was her extraordinary proportion of length to beam, and her ratio of 10¼ to 1 in that respect was considered a remarkable venture on the part of her builders, Harland & Wolff, of Belfast. The rapid progress of the times soon distanced her in the North Atlantic race, and she was transferred to the Pacific.

The White Star Company was so well pleased with the result of its first experiment at lowering the record that its managers at once decided to reinforce their line with two new ships, the *Adriatic* and *Celtic*, brought out in 1871-72. These were sister ships in general dimensions, model, and engine power, and were designed to embody certain improvements which the experience of the *Oceanic* had made apparently advisable. The only difference between them was in the arrangement of the decks, which need not be described in detail here.

The *Adriatic* and *Celtic* tonned 3,886 gross, on dimensions of 417 ft. long by 41 ft. beam, and they were propelled by four-cylinder, compound engines, of which the two high-pressure cylinders were each 41 in., and the two low pressures 78 in. diameter, with a 60-in. stroke; and, carrying 80 lbs. of steam, they developed 3,880 indicated H.P. They again reduced the transatlantic passage time below the *Oceanic's* record, the *Adriatic* making her best westward trip in 7 days, 16 hours, and 26 minutes from Daunt's Rock to Sandy Hook, and her eastward run in 7 days, 19 hours, and 43 minutes. The *Celtic* was never quite able to meet the record of her sister ship, her best trip being 7 days, 21 hours, and 55 minutes eastward. The difference, however, was no more than might have been due to ordinary vicissitudes of passage, and afforded only another of many proofs that no matter how faithfully sister ships may be duplicated in build, there will always be slight variations in performance.

These early ships of the White Star Line displayed prominently the genius of Mr. Edward J. Harland, the head of the Belfast firm and also its chief naval architect, and he soon received the honor of knighthood in recognition of his services to the public.

While these enterprises of the White Star Line were in progress, a movement was started on this side of the ocean, which at first bid fair to permanently enlist American capital and national spirit in an effort to regain the position of a maritime commercial power which our country had lost through the Civil War. The immediate upshot of this movement was the formation of the American Steamship Company, and the construction by the Cramp Company of four steamships known as the *Indiana*, *Illinois*, *Pennsylvania*, and *Ohio*. There were at that time indications that the policy of the general Govern-

* Presented at the New York meeting of the Society of Naval Architects and Marine Engineers.

ment toward the national merchant marine would be liberal, and it is probable that these indications had some bearing upon the action of the American Steamship Company; but if so, the policy was altered too soon to realize any benefit, and its subsequent career presented the aspect of an unequal and, of course, unsuccessful contest between an unaided American private enterprise and British competitors backed by all the resources of their powerful Government.

The four ships of the American Line were commissioned in 1872–73. They are 357 ft. long over all, and 243 ft. between perpendiculars, 43 ft. beam, with a tonnage depth of 24 ft., United States measurement, and their gross register is 3,126 tons. They were powered with two-cylinder, compound engines, having piston diameters of 48 and 90 in., with 48-in. stroke; and, carrying 75 lbs. of steam pressure, they developed about 2,000 H.P., which gave them an average speed of 14 knots. They made 8-day trips, and for a time attracted their share of the transatlantic traffic, but, as already intimated, they succumbed at length to the competition of their subsidized British rivals and ultimately passed under the control of the International Navigation Company, by whom they have been considered worth reequipment with new triple-expansion engines after 20 years of continuous service. These ships, though not so large or so high powered as some contemporary vessels, embodied the best shipbuilding practice of their date as to material and workmanship, and are still creditable specimens of American shipbuilding skill 20 years ago, as well as of first-rate efficiency in their classes.

Suffice it to say, that for more than two decades they have had the melancholy distinction of being the only merchant steamships to show the Stars and Stripes regularly in the ports of Western Europe, and in the 300 and odd passages that each of them has made, their performance has invariably been excellent. At any rate, though overshadowed in size and distanced in speed by later products of the fierce competition which has followed their advent, the four "American ships" have served to tide the name of the American merchant marine over a score of dreary and disheartening years, and now, in the dawn of a brighter epoch, they remain sturdy links connecting the promise of the future with the glories of the past. It has been no easy errand to keep the American flag fluttering on a North Atlantic steamship since 1872, but these four ships have done it, and I feel that in the present reawakening of our national maritime spirit, the public will pardon my pride in them as part of the work of our establishment. They are soon to be reinforced in the task of keeping our flag afloat by new and powerful coadjutors whose proportions and performance will restore our ocean prestige to the best relative rank it ever enjoyed; but when that time comes it will still be worth while to remember that it was the *Ohio*, the *Indiana*, the *Illinois*, and the *Pennsylvania* which for 20 years alone represented in our merchant marine the motto of Lawrence in our Navy, "Don't give up the ship!"

Resuming consideration of operations abroad, we observe that the Inman Company did not rest content under the lead which the White Star people had established in 1871–72, but in 1873 they brought out two new ships, the *City of Chester*, built by Caird & Co., of Greenock, and the *City of Richmond*, by Tod & McGregor, of Glasgow. These ships were nearly equal in gross register, the *Chester* being 4,770 tons and the *Richmond* 4,780, but they differed considerably in model and machinery. The *Chester* was 444 ft. long, 44 ft. beam, with a tonnage depth of 34 ft. Her power was a two-cylinder compound engine, with cylinder diameters of 68 and 120 in. and 66-in. stroke, which, with steam at 65 lbs., developed about 4,300 H.P. Although these new Inman ships were considerably larger than their contemporaries and competitors of the White Star Line, and had about 35 per cent. more power, they did not meet the anticipation of their owners so far as the existing record was concerned. At all events, the *Adriatic* held the record through 1873.

Meantime the Inman Company renewed its efforts, resulting in the award of a contract during 1873 to Caird & Co., Greenock, to build the *City of Berlin*. This was a vessel of 5,490 tons gross, 499 ft. long, 44 ft. beam, with a tonnage depth of 34 ft. She was powered with a two-cylinder compound engine, high-pressure cylinders 72 in., low 120 in., stroke 66 in., and, with steam at 75 lbs., the indicated H.P. was 5,200. The *City of Berlin* was distinguished by having the greatest proportion of length to breadth thus far attained—namely, 11 to 1. In other respects the *Berlin* was the finest ship of her time, and she brought the record down to 7 days, 15 hours, and 28 minutes.

Pending this activity of the Inmans, the White Star people were by no means idle, but contemporaneously brought out the *Germanic* and *Britannic*, within a few months of each other, from the Belfast yard of Harland & Wolff. These sister ships are 455 ft. long, 45 ft. beam, and 33 ft. measured depth, their gross tonnage being 5,008. Their motive power was compound, of four-cylinder type, the two high-pressure cylinders having a diameter of 48 in. and the two lows 83 in. each, with 60-in. stroke, and, carrying 75 lbs., their indicated H.P. has reached 5,600.

These ships brought the record down to 7 days, 6 hours, and 52 minutes, and they are still in service in the main fleet of the White Star Line, the *Britannic* having made an average of 7 days, 16 hours, and 9 minutes in 12 trips during the year 1891, or an average all-the-way speed of 16 knots.

From 1874 to 1879 the *Germanic* and *Britannic* easily held the pennant. In the latter year the Cunard people, who had hitherto rested content with their reputation for safety, without joining in the contest for speed, brought out the *Gallia*, built by the Thompsons, of Clydebank. The *Gallia* is a trifle smaller than her White Star rivals. She is 430 ft. long, 44 ft. beam, and 34 ft. tonnage depth, her gross register being 4,809 tons. Her power is a three-cylinder compound engine, the high-pressure cylinder 64 in. and the two lows 90 in. each, with 60-in. stroke, developing 4,440 indicated H.P. This ship, though a distinct advance upon anything yet brought under the Cunard flag, did not affect the White Star championship, as the *Gallia*, in her best passage of 7 days, 16 hours, and 32 minutes, fell 9 hours and 40 minutes behind the best record of the *Britannic*.

In the same season, however (1879), the Guion Line—a new Richmond in this particular field, by the way—brought out the *Arizona*, built at Elder's, and with her took the pennant so long borne by the White Star ships. The principal dimensions of the *Arizona* are 450 × 45.4 × 35.7 ft., and she is powered with three-cylinder compound engines having one 62 in. high and two 90-in. low-pressure cylinders, 66-in. stroke, and, with steam at 90 lbs., developed 6,640 indicated H.P. Her gross tonnage is 5,164, and her best trip was made in 7 days, 3 hours, and 38 minutes, involving an average all-the-way speed of 16.27 knots an hour. The *Arizona* carried the banner, by virtue of this performance, two seasons—1879 and 1880.

This success of the *Arizona* stimulated the Guion people to renewed efforts, and in 1881 they brought out the *Alaska*, also built at Elder's (or the Fairfield yard), then under the able management of the late Sir William Pearce.

The *Alaska's* dimensions are 500 × 50 × 38 ft. molded, with a gross tonnage of 9,500, and her power is a three-cylinder compound engine having a 68-in. high-pressure and two 100-in. low-pressure cylinders, which, carrying boiler steam at 100 lbs., developed in a mean of four days' performances 11,800 indicated H.P., and drove her across the Atlantic westward in 6 days, 18 hours, and 47 minutes, which involved an all-the-way mean speed of 17.44 knots per hour. The *Alaska* now took the pennant, but she did not hold it long. The Barrow Shipbuilding Company brought out the *City of Rome* the same year, and that vessel was put in the service by the Inman Line, as I understand, the title to the ship remaining with her builders.

The contest between the *Alaska* and the *Rome* was fierce. Trip after trip they sped over the ocean "neck and neck," as horsemen say, the average difference between their records being but a few minutes. Finally, however, the *Rome* got down to 6 days and 18 hours, which beat the *Alaska's* best by 37 minutes, and then the *Rome* hoisted the banner in her turn. The *Rome* was the largest ship of her day, excepting, of course, the *Great Eastern*; at all events, the largest single-screw ship up to her date. Her dimensions are 560 × 52 × 37 ft., her gross tonnage 8,144, and her maximum H.P. 11,500 indicated. The *Rome* underwent some vicissitudes in her early history. Her first service in the Inman Line was not satisfactory, and she was thrown back on the hands of her builders. They then made considerable alterations of boiler arrangement and other details of internal economy, and she was put in service again by the Anchor Line, where she has remained to this time.

During the year 1881 the Cunard Company brought out the *Servia*, built, as the *Gallia* was, by Thompsons. The *Servia's* dimensions are 515 × 53 × 37 ft., and her gross register is 7,392 tons. Though a fine ship, the *Servia* repeated the disappointment of the *Gallia*, by failing to reduce the record of either the *Alaska* or the *Rome*. Her propulsion was by a three-cylinder compound engine having one 72-in. high and two 100-in. low-pressures, with 72-in. stroke, and, carrying 90 lbs. of steam, she developed 10,200 indicated H.P. in her best trip, which was 6 days, 23 hours, 49 minutes.

The year 1882 may be considered as the end of the supremacy of 7-day ships, because, though the *Alaska* and the *Rome* subsequently got inside that limit, it was only to a small degree, and the performance was not maintained, so that they remained properly in the 7-day class.

The spring of 1883 witnessed another distinct stride of progress. Thompsons built the *America* for the National Line and the *Aurania* for the Cunards, while Sir William Pearce, of Elders, built the *Oregon* for the Guion Line.

The *America* was in several respects a departure from the then current fashion in transatlantic liners. She was shorter, proportionately beamier, and much smaller in tonnage than her chief rival, the *Oregon*. The dimensions of the *America* were 441 × 51 × 36 ft., gross tonnage 5,528, and her displacement at 25 ft. draft was 9,550 tons. Her engines were compound, three cylinders, high-pressure, 63 in.; two lows, 91 in.; with 66 in. stroke. Carrying 95 lbs. of steam, the *America* developed 9,500 H.P., and crossed the Atlantic in 6 days, 14 hours, and 16 minutes, at a sustained speed of 18.41 knots an hour. Though perhaps the smartest ship of her time, the *America* proved unprofitable, because her carrying capacity was too small in proportion to her operating cost. Fortunately for her owners, the "Russian scare" in 1885 caused her to be taken by the British Government as an auxiliary cruiser, and when she was discharged from that service she was purchased by Italy for use as an armed transport and torpedo depot ship, in which service she has since figured under the name of the *Ecritree*.

The *Oregon* was 501 × 54 × 38 ft., 7,375 tons gross register, and at 25 ft. draft displaced 12,560 tons. Her engines were three-cylinder compound, of the highest working pressure attempted up to that time. Her high-pressure cylinder was 70 in. and her two lows 104 in., with 72-in. stroke, and, carrying steam at 110 lbs., she developed 13,200 H.P., by far the most massive and powerful engines built at that date. The *Oregon's* best performance was an all-the-way speed of 18.58 knots, which gave her a record of 6 days, 9 hours, and 22 minutes. She was also taken up as an auxiliary cruiser during the "Russian scare," and on her release was purchased by the Cunard Company, in whose service she remained until sunk by collision off Long Island.

The *Aurania* is 470 × 57 × 37 ft., 7,269 tons gross, and, at 26 ft. draft, displaces 12,360 tons. Her engines are three-cylinder compound, high-pressure 68 in., two lows 91 in., with 72-in. stroke. Carrying 90 lbs. of steam, she developed a mean of 8,850 H.P., producing an all the-way speed of 17.21 knots. This gave her a record of 6 days, 20 hours, and 48 minutes. Like the *Gallia* and the *Servia*, she was a disappointment to the public in speed.

The Cunard Company continued their development, however, and in 1884-85 brought out the *Umbria* and *Etruria*, built at Fairfield. These sister ships are 501 × 57 × 38 ft., 8,120 tons gross register, and, at 26 ft. draft, displace 13,380 tons of water. They were powered with three-cylinder compound engines of the usual Fairfield type of that day, and differed but little from those of the *Oregon*. The high-pressure cylinder was 71 in., the two lows 105 in., with 72-in. stroke, and, with 110 lbs. of steam, their maximum development of H.P. has been 14,840 in the *Etruria*, and 14,460 in the *Umbria*. They reduced the record to about 6 days even, though each has made at least one passage slightly inside of six days. They brought the Cunard Line to the front again for the first time in several years. From 1884 to 1889 the *Umbria* and *Etruria* maintained their supremacy. It was evident that in them the possibilities of single screw propulsion had been exhausted, and owners and builders who meditated an advance beyond them had to contemplate twin screws.

During the years 1885, 1886, and 1887 there was much activity on the part of the French and Germans. The latter brought out the *Aller*, of the North German Lloyds, in 1885, the *Saale* and *Trave* in 1886, and the *Lahn* in 1887. These were British ships built at Fairfield. They were all single-screw vessels, but they had the distinction of introducing the triple-expansion engine in transatlantic propulsion. The *Aller*, *Trave*, and *Saale* are substantially alike in hull and fittings, and their engines are exact duplicates, except in certain minor or non-essential parts. These vessels are 439 × 18 × 34 ft., and register 4,994 tons in the *Aller* to 5,380 in the *Trave* and *Saale*, their displacement at 26 ft. draft being 10,400 tons. Their triple-expansion engines have high-pressure cylinder 44 in., intermediate 70, and low 108 in., with 72-in. stroke. Carrying steam at 150 lbs., these engines have developed 8,300 indicated H.P., and their best sustained speeds have been 17.7 knots for the *Aller*, 17.1 for the *Saale*, and 18.6 for the *Trave*. As the time of these ships is reckoned from Southampton, certain deductions are necessary for fair comparison with ships dating from Queenstown, so it is not worth while to give their records, except to say that to equalize the records of ships starting from the two points, allowances must be made in favor of the Southampton ship as follows:

For 17 knots speed, 16 hours and 20 minutes.
For 17½ knots speed, 16 hours.
For 18 knots speed, 15 hours and 30 minutes.
For 18½ knots speed, 14 hours and 56 minutes.
For 19½ knots speed, 14 hours.

The *Lahn* is 10 ft. longer, 1 ft. wider, and 10 in. deeper than her three consorts, and her gross tonnage is 5,681. Her engines are also of a different type, being five-cylinder triple-expansion with two high-pressure cylinders 32½ in., one intermediate 68 in., and two lows each 85 in., the duplicate cylinders being arranged tandem, one high and one low working together. These engines, with 150 lbs. of steam, developed 9,800 H.P., and produced a speed of 18.40 knots, making a Southampton record of 6 days, 22 hours, and 42 minutes, which, at her rate of speed, is equal to a Queenstown passage of 6 days, 7 hours, and 30 minutes.

The *Spree* and *Havel*, built at Stettin, in 1890, for the North German Lloyds present no features essentially different from the *Lahn*, except some increase in size, and as they have not lowered her record it is not worth while to go into details of them.

In 1889-90 the successes of their neighbors stimulated the Hamburg Company to efforts which took shape in the *Columbia*, *Normannia*, and *Prince Bismarck*. The *Columbia* was built by Lairds, and *Normannia* at Fairfield; the *Bismarck* being the only one of the three built at home. The *Columbia's* dimensions are 463.5 × 55.6 × 35.5, and her gross register is 7,363 tons. Her twin screws are driven by two three-cylinder, triple-expansion engines, with cylinder diameters of 41, 66, and 100 in. and 66-in. stroke. With steam at 150 lbs. these engines have developed 14,600 collective indicated H.P., producing mean speed for a passage of 19.15 knots, and a Southampton record of 6 days, 14 hours, and 2 minutes, equivalent to a Queenstown record of about 6 days. The *Normannia* is larger than the *Columbia* and has more powerful machinery.

The *Normannia's* dimensions are 500 × 57.5 × 34, and she tons 8,250. Her triple-expansion engines have cylinders 40, 67, and 106 in., with 66-in. stroke, and carrying steam at 150 lbs., they have developed over 15,000 indicated H.P. Her best mean speed for a passage has been 19.33 knots. The *Fürst Bismarck* is chiefly remarkable as being the most important commercial ship ever built in Germany, and as a result of the policy adopted by the German Emperor to encourage home shipbuilding by making marked discriminations in favor of such ships as compared with those built abroad. Her dimensions are 502.6 × 57.6 × 38, and her tonnage 8,874. Her engines are triple, with cylinder-diameters of $43\frac{5}{16}$, $66\frac{9}{16}$, and $106\frac{5}{16}$ in., having a stroke of 63 in. She is reported to have developed 16,800 indicated H.P., as a mean of 6 days on the trip which gave her, for a brief period, the Southampton record.

During all this effort on the part of the English and Germans, the French remained quiescent until 1886-87, when they brought forward the *Champagne* and *Bretagne*, built at St. Nazaire, and the *Bourgogne* and *Gascogne*, built by the *Forges et Chantiers de la Mediterranee*. These ships differ but little in dimensions or performance, and detail of them is hardly necessary, except to say that they ton from 7,087 to 7,395 gross, have compound engines of about 9,800 indicated H.P. on a single screw, and the smartest of them, the *Bourgogne*, has made a Havre and Sandy Hook record of 7 days and 9 hours, which, at her rate of speed, 17.91 knots, is equal to a Queenstown record of 6 days and 13 hours. These ships satisfied the French until 1891, when they brought out the *Touraine*, built at St. Nazaire. She is the first French liner equipped with twin screws. Her dimensions are 520 × 56 × 34 ft., and she tons 8,863 gross. Her engines are three-cylinder, triple-expansion. Cylinder dimensions 41, 60½, and 100 in., with 65-in. stroke, and, carrying 140 lbs. of steam, they have developed a mean average of 13,600 indicated H.P. (French), which drove her from Havre to Sandy Hook in 7 days, 3 hours, and 5 minutes, equivalent to a Queenstown record of 6 days, 4 hours, and 35 minutes.

While the *Touraine* has not made any whole-trip record to compare with the *Paris* or *Teutonic*, she has shown some remarkable spurts.

Externally, the *Touraine* is one of the handsomest ships afloat, and her interior fittings sustain the repute of French builders for grace and elegance.

I have given considerable time to this detail of dimension and performance, because I have often desired to have such a compilation in good shape for ready reference; but not being able to find one concluded to make it myself. It is not possible to survey the evolution of the Atlantic greyhound without such reference, because in the absence of data as to dimensions and power, discussion of relative performance would be without result.

We have now to consider the latest types, the *New York* and

Paris, the *Majestic* and *Teutonic*, and the *Campania* and *Lucania*.

These ships are so well known and have been so recently and minutely described that it is not necessary to reproduce their details, and I will pass at once to another, and, perhaps, more interesting phase of my subject, but before passing on. it should be mentioned that to the International Navigation Company in procuring the building of the *New York* and *Paris* belongs the credit of inaugurating the evolution from single to twin screws in passenger ships, and of first offering to the public steamships so subdivided as to be unsinkable with three compartments flooded and with no water-tight doors near or under the water-line.

However, in all the progress that I have noted there has been no improvement of model, or at least none worth noting.

The principal fad of the great English builders is an aversion to statical stability; a repugnance to metacentric height. As one of their standard authorities remarked in a recent paper, "A ship will roll; you cannot help that. Therefore the problem is to make her period as long and her motion as easy as possible."

Even if this be true in theory the practices by which they seek to put it in effect are based upon error.

In pursuit of "an easy roll" they persistently design their models without initial stability, and then make them stand up by great quantities of water ballast or other dead weight which pays nothing.

When I undertook the design of the two steamships now building under our shipyard numbers 277 and 278, I avoided this fad at the outset.

As a part of the discussion which followed I addressed, at his request, the President of the International Navigation Company in writing as follows:

"Any system of design or construction which contemplates the carriage of water ballast (or other dead weight not cargo or coal) as an inseparable condition of stability under any circumstances is radically defective, and should be condemned. Of course every double-bottom ship should be so compartmented that the spaces may be used as trimming tanks for regulating fore-and-aft trim when desired, but I utterly reject and condemn any system under which they must be viewed as necessary adjuncts to stability.

"Under such a system no advantage can be taken of decreased draft caused by consumption of coal or absence of cargo, but the ship must always be kept down to a load draft in order to stand up. This is a purely English fad, and the English designers stick to it with characteristic tenacity. In this, as in many other fads, the English appear tenacious in the exact ratio of the density of their error.

"The proposition that you must carry 1,000 or 2,000 tons of dead weight in water ballast when you happen to be short of cargo or run down in coal, is one that I cannot really discuss with patience when it is possible to build the ship on lines that will make her stand alone without detriment to any other desirable quality, and with vast improvement to her most important characteristic, that of safety at all times and in all conditions."

One cannot conveniently amplify technical propositions in a business letter, and hence in my communication I merely touched the heads of my topic, and referred to the most important consideration last and also most briefly—that of safety at all times and in all conditions.

From this point of view I dismiss the commercial aspect of water ballast or permanent dead weight with the remark that any steamship owner who will accept a design that compels him to lug around 1,000 tons or so of non-paying freight in a bottom during the life of his ship, deserves what he gets, and is not entitled to sympathy.

In connection with the conventional English plan of indispensable water ballast, there has been suggested as an ultimate refinement a system of ingress and expulsion of water to and from numerous compartments by means of valve and pump-gear under electric control from a central station. Let us suppose such a system so perfectly developed that an operator can sit at an electric keyboard with a button for each valve and for each pump, and there operate them as Paderewski plays the piano. This may be very pretty and very scientific, but, after all, it involves the human factor, with its liability to err, in a manner that places the lives of a thousand passengers at the fingers' ends of the operator. I have, during 40 years of observation and experience in my profession, seen so much of the human factor under such circumstances that the elimination of it in every possible direction has almost become a passion with me. In any ship design it is a first principle with me to provide as many absolute and unchangeable qualities of performance and safety as possible, and to place them beyond manipulation.

The first and most important of such qualities is that of initial stability. With it the ship will stand up and float despite errors or misfortunes of management or condition. Without it she and all on board may at any time be at the mercy of a tipsy tank trimmer, or of a jammed valve.

With regard to the increase of size as an element in the development of speed, I think we may all agree with Dr. Francis Elgar in his paper read before the British Institution of Naval Architects July 11 last, that the limit of commercial practicability has been reached. The operation of Froude's well-known law of comparison, whereby the ratio of indicated H.P. required to drive a ton of displacement at a given speed decreases in a certain progressive ratio as the increase of dimensions, naturally led up to the *Campania*.

But hydrographic conditions are inexorable, and they impose an unalterable limitation of one dimension—namely, draft of water, which, in turn, imposes an architectural limitation upon all the other dimensions. Dr. Elgar hopes that this limitation will be enlarged by dredging away bars and deepening docks, so that 30 ft. of water may be had where only 26 ft. now exist, so that it might become practicable to design a ship on the dimensions permissible with 30 ft. draft. That would, perhaps, mean a ship about 700 ft. long and 75 to 80 ft. beam. But it is not worth while at this time to consider such a contingency. The practical commercial limit of our metropolitan seaport is about 28 ft., and it would require an expenditure of more millions than one cares to contemplate to augment it to admit the safe passage of a steamer drawing 30 ft. either in channel or at dock, so we might as well accept 28 ft. as the basis of design in our time.

There is another limitation to practicable size which has not been mentioned—the ship may become too large for the captain. It is the fact that while we may increase dimensions of ships, the size of man is a fixed quantity. I mean this in the physical as well as the mental sense. A ship is not like an army, which can be divided in sections, each capable of independent motion. She must be commanded and manœuvred in one piece and by one man.

The ratio of beam to draft in the immersed body ought never to exceed 3 to 1, and is doubtless best at about $2\frac{1}{2}$ or $2\frac{3}{4}$ to 1. All the elements of model, lines, girder strength, stability, easy motion, and structural symmetry are involved in this ratio of dimensions, because the length is limited by the other two. We cannot go above a certain molded depth without getting the top sides too high, and we cannot otherwise get the necessary girder strength beyond a certain length.

Therefore, on a basis of 28 ft. draft we may have a beam of about 70, molded depth approximating 50, and a length of 600 to 620 ft. That seems to be about the end. In contemplating such ships the problems of structure and propulsion assume added importance proportionate to the dimensions.

Of course, the equivalent girder circulation can be made in a 620-ft. ship as well as in a shorter one, but it is probable that in such great lengths and with such stresses of power as are applied to that class of vessels larger margins of safety should be allowed than is the practice in computing smaller girders. At any rate, I should do so in designing any such ships.

A 600 or 620-ft. ship that will work her framing or buckle her plates in a sea-way is not a good piece of property. Butt-starting, seam-opening, and rivet-shearing are only questions of time in such a ship, and the danger increases with the size in a high ratio.

We may now consider briefly the question of propulsion, which I will introduce by a further quotation from the letter to the President of the International Navigation Company, already referred to. Arguing that the limitations of practicable power in one engine were quite as definite as those of size in ships and for cognate reasons, I wrote as follows:

"The most important practical reason for the distribution of power through two or more screws, instead of concentrating it in one, is the limitation placed upon the effective or economical diameter of the screw itself by the inexorable conditions of draft.

"Reduction in size and weight of forgings, decrease of danger of total disablement, etc., are the plainest and simplest elements of the question, and are so well known and generally accepted as to hardly require attention.

"You must have a certain immersion of the screw, the more the better; it should be at least 9 ft.—that is, the top of the disk should be about 9 ft. below the surface. Now as the hydrographic conditions of our Atlantic Coast harbors practically restrict draft to 27 or 28 ft., it follows that the maximum diameter of a screw is limited.

"Again, unless you give your engine much higher revolutions than is desirable or economical in machines under existing conditions, which must be driven at full speed five or six

days at a stretch, you cannot put more than 12,000 indicated H.P. through one screw.

"These facts, with the force of a syllogism, demonstrate that whenever you require more than 12,000 indicated H.P. you must have two screws, and if you find it necessary to exceed 24,000 indicated H.P. three will be required.

"There is absolutely no escape from this proposition ; no alternative in practice ; and volumes enough to make a library, by all the professors in the world, cannot alter the plain, mechanical fact.

"An English authority has recently called attention to an alleged greater tendency of twin screws to 'race when rolling,' and that if instead of the two screws there were three, the extension of the side screws laterally would tend to reduce the advantage of smaller diameters, etc. This statement is disposed of by the remark that what causes racing is the pitching of the ship, which affects all the screws alike, when in the same horizontal plane, but with the counter screws sufficiently immersed no properly built ship would roll enough to seriously affect their efficiency.

"It will not do to treat this question as if it referred to all classes of ships alike. The question is not as to the relative advantage of single, twin, or triple screws, *per se*, in any and all kinds of ships, but as to the limit of dimensions in one engine and screw for safe and economical working. When we want to power a ship beyond that limit we must duplicate or triplicate the engines and screws in due ratio.

"No one, so far as I know, maintains that, except in men-of-war and for tactical reasons mainly, and for additional safety, two screws ought to be used when one will do the work, or three where two can do it. Some lake and river boats have two screws, but in such cases the object is to facilitate landing at wharves or because the draft is insufficient to afford diameter enough for one screw to take the power. But in sea-going vessels such construction would not apply."

These remarks are based on existing conditions of practice. The future may develop modifying results. But men do not build ships on a prediction. Hence I limit my views by what we now know.

I hope that the members of the Society will not expect me to say very much about the efforts which are now being put forth to restore the American flag to its proper rank in the contest of the North Atlantic. We are, as is well known, building a couple of 536-ft. ships for the International Navigation Company. They are both framed up about two-thirds of their length amidships, and plating is in progress. They will be launched next spring and will go in commission about a year from now.

Their principal dimensions and qualities are as follows :

Length on load water-line..........	536 ft.
Length over all....................	554 "
Extreme breadth....................	63 "
Molded depth.......................	42 "
Gross register.....................	about 11,000 tons.
First cabin capacity...............	320 passengers.
Second cabin capacity..............	200 "
Third cabin capacity...............	900 "

Their propulsion will be by twin screws, actuated by two quadruple-expansion engines, on four cranks, which, with steam at 200 lbs., will probably develop about 20,000 collective indicated H.P. To support the outboard shaft bearings the hull is built out in a horizontal web to a steel frame having both bosses cast in one piece and weighing about 68,000 lbs. The after deadwood is cut away and the keel slopes up so that the shoe meets the boss frame at the after end. It will be observed that these ships are considerably larger than the *New York* and *Paris*, or about half-way between them and the *Campania* class. I will not venture a prediction as to their probable performance, but I will guarantee them to be perfectly safe, comfortable, and economical ships.

They are to be followed closely by other ships, which I will not now describe, except to say that they will not shrink from any comparison or competition.

The conditions of the mail contract between the Government and the International Navigation Company, place at the disposal of the Navy seven great ships, almost instantly convertible into commerce destroyers, averaging greater performance than the *Columbia* and *Minneapolis*. This practically reinforces the Navy by $21,000,000 worth of ships, and that not only without cost of building, but also without the expense of maintenance and commission in time of peace.

From this point of view, the policy of the International Navigation Company, of which these ships are the result, appeals to the best and loftiest public sense. It is more than a mere commercial enterprise. It is as bold a stroke of national ambition and patriotic aspiration as was ever made. It aims at achievements the beneficial results of which will be felt in every household throughout our broad land.

And now, in conclusion, let me remark that these ships are American from truck to keelson. No foreign materials enter into their construction. They are of American model and design, of American material, and they are being built by American skill and muscle. The existing tariff law, Section VIII, gives the privilege of importing all "plates, tees, beams, angles, wire rope and composition metals" that might be needed in their construction. But I did not take advantage of it. On the contrary, we placed every order with American rolling mills, forges, and foundries.

In view of such a situation, why should any one persist in threatening with hostile and destructive legislation those who are making such efforts in the face of such obstacles? No American shipowner or shipbuilder asks for free ships. The demand for such a law comes from England, not from our own people. All that Americans ask is to be let alone.

Since we began this work our English friends have had a good deal to say about it. They seem to think that it was impertinence on our part to have entered the contest for supremacy on the North Atlantic. They deprecate the fact exceedingly. But they may as well understand that, after many years of practical expulsion from the ocean, the Yankees are coming again, and coming to stay. The work we have in hand is only the beginning. It is a pretty fair start, but if they should ask you what the future has in store you may tell them, in the words of our Paul Jones on a certain occasion, well remembered by Englishmen, that "we are just beginning to fight."

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

The object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in October, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN OCTOBER.

Phillipsburg, N. J., October 2.—A steam-pipe burst on an engine of the Jersey Central Railroad while running at full speed to-day. In order to stop the train it was necessary to stand where the steam was blowing out. The engineer, Joseph Lutz, did this, and was terribly scalded ; he fainted as he staggered from the cab.

Parkersburg, W. Va., October 2.—Patrick Connelly, an engineer on the Baltimore & Ohio Railroad, was run down by a passenger train to-day, and died from his injuries.

Springfield, Wis., October 2.—Passenger train No. 4, on the Chicago, Milwaukee & St. Paul Railroad, ran into an open switch at Lyman, dashing through three stock cars and instantly killing the engineer, Maxey Hall, and fireman, Charles Robinson. It is reported that this is a third attempt at train wrecking.

Milford, Mass., October 2.—Fireman Hennessey, on the Grafton & Upton Railway, was severely scalded about the face and head to-day while filling a lubricator, by steam escaping from the boiler. The flesh peeled off in flakes.

Easton, Pa., October 3.—A Lehigh Valley coal engine cut a Crane Iron Company's engine in two at Catasaqua this morning. A dozen coal cars were wrecked and all travel blocked. The collision was due to a signal giving a clear track to both engineers by a watchman who had been in the position for more than 20 years. After he saw what he had done he went home and shot himself. John Ray, fireman on the Crane Company's engine, died of injuries received, and Engineer Herbert James will be a cripple for life.

LOCOMOTIVE RETURNS FOR THE MONTH OF AUGUST, 1893.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Locomotive Mileage. Freight Trains.	Locomotive Mileage. Service and Switching.	Locomotive Mileage. Total.	Locomotive Mileage. Average per Engine.	Av. Train. Passenger Cars.	Av. Train. Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Coal Burned per Mile. Freight Train Mile.	Coal Burned per Mile. Service and Switching Mile.	Coal Burned per Mile. Train Mile, all Service.	Coal Burned per Mile. Passenger Car Mile.	Coal Burned per Mile. Freight Car Mile.	Cost per Locomotive Mile. Repairs.	Cost per Locomotive Mile. Fuel.	Cost per Locomotive Mile. Oil, Tallow and Waste.	Cost per Locomotive Mile. Other Accounts.	Cost per Locomotive Mile. Engineers and Firemen.	Cost per Locomotive Mile. Wiping, etc.	Cost per Locomotive Mile. Total.	Cost per Car Mile. Passenger.	Cost per Car Mile. Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé																									
Canadian Pacific	615		562,022	715,582	567,676	1,845,280	3,000						63.91			3.46	10.16	0.34		5.65	1.26	20.87			3.15
Chic., Burlington & Quincy	541					1,563,418	2,889	5.77	19.39				77.27			5.29	5.11	0.23	0.15	6.78	0.05	17.61			1.82
Chic., Milwaukee & St. Paul	828					2,272,886	2,649						63.27			3.44	6.60	0.28		6.92		17.24			2.40
Chic., Rock Island & Pacific	565		609,634	919,110	344,214	1,872,958	2,643			55.04	76.45	38.00	62.38			2.84	5.65	0.25	4.28	5.99	0.38	14.69			1.96
Chicago & Northwestern	888		787,814	1,152,341	639,000	2,869,155	2,893						79.57			3.06	7.60	0.35		6.37	0.82	18.2			1.90
Cincinnati Southern																									
Cumberland & Penn.*		23	5,639	34,852		40,491	1,760									7.03	4.43	0.04			1.86	13.72			
Delaware, Lackawanna & W. Main L.	211	172				590,026	3,430						84.35			3.21	6.53	0.46		5.77		15.97			
Morris & Essex Division	160		188,901	152,792	76,333	418,026	2,612						55.97			3.67	8.84	0.44		6.35		19.30			3.12
Hannibal & St. Joseph		74				248,931	3,556	5.93	16.54				75.88	13.83	5.29	2.99	4.87	0.10	0.25	6.75	0.03	14.99			1.86
Kansas City, F. S. & Memphis			101,051	167,939	86,000	354,990							60.65			3.71	5.49	0.36	0.45	7.46		17.47			1.75
Kan. City, Mem. & Birm	42	38	36,676	44,664	13,459	94,799	2,495						66.58			4.17	3.48	0.22	0.35	7.12		15.34			1.00
Kan. City, St. Jo. & Council Bluffs	37	37				126,529	3,430	5.02	18.67				61.46	12.57	4.85	3.63	5.54	0.15	0.06	6.12	0.02	15.52			1.90
Lake Shore & Mich. Southern	599		484,450	625,722	409,476	1,519,648	2,537			59.66	84.96	34.70	62.87			2.83	4.88	0.18		6.87	0.20	14.96			1.54
Louisville & Nashville																									
Manhattan Elevated		273	708,103		64,583	772,686	2,830						38.46			1.60	7.80	0.20		9.40		19.00			4.08
Mexican Central	148	119				376,740							68.49			5.89	13.30	0.55	0.21	4.78	0.83	25.56			4.29
Mil., L. S. & Western	112		94,807	118,247	64,855	277,909	2,481						66.18			3.72	7.29	0.16		6.09	0.91	18.17			2.20
Minn., St. Paul & Sault Ste. Marie			77,489	158,550	87,524	323,568		4.76	20.08				63.25			1.73	11.67	0.24		6.06		19.90			3.73
Missouri Pacific	342					979,113	3,291	4.41	16.21				77.22			4.90	5.48	0.33	1.05	6.29	1.39	19.44	3.98	1.43	1.88
Mobile & Ohio	107	70	75,349	99,135	49,588	224,072	3,201		22.30				54.68			1.10	3.91	0.19	0.78	5.71	1.04	12.73			1.43
N. O. and Northeastern																									
N. Y., Lake Erie & Western	627	417	500,520	794,703	259,489	1,554,712	3,728	5.20	23.40	86.50	126.50	63.45	92.15	16.50	5.40	3.91	7.07	0.38	2.68	7.30	1.18	22.52			1.38
N. Y., Pennsylvania & Ohio	254	167	176,680	392,166	140,509	709,355	4,247	6.30	18.20	72.60	123.70	84.35	93.55			2.69	5.71	0.29	4.17	6.73	0.96	20.55			1.12
Norfolk & Western, Gen. East. Div.†			125,492	262,041	51,503	439,036	2,710	4.20	18.60	46.08	116.63		81.37	9.30	5.60	3.10	3.80	0.40				7.30			
General Western Division†			119,948	269,726	42,746	432,420	2,496	5.20	17.20	66.00	121.00		110.00	12.10	7.52	4.20	4.30	0.35				8.95			
Ohio and Mississippi	107		146,937	133,304	86,330	366,571	3,425						75.47			2.42	2.94	0.23	1.30	5.33	1.52	13.74			0.78
Old Colony																									
Philadelphia & Reading			497,818	324,964	947,469	1,770,251							73.58			4.59	4.10	0.32		5.72	0.40	15.13			
Southern Pacific, Pacific System	785	663	649,064	864,527	278,565	1,792,156	2,703	5.41	4.85				67.52			4.06	16.81	0.22	2.30	7.39	1.12	31.90			5.01
Union Pacific	992		574,554	1,047,503	317,797	1,939,854	3,208	6.14	17.53				94.38			6.75	9.16	0.48	0.94	8.16	1.24	26.68	3.99	1.88	1.92
Wabash	425	362	452,921	640,006	242,859	1,355,786	3,680	5.02	16.70	65.74	93.28	55.14	78.33			3.27	4.52	0.30		6.18	0.83	15.10	2.50	1.00	1.17
Wisconsin Central	150	117	129,238	196,779	63,436	390,446	3,334						73.19			2.04	8.95	0.20		7.14		18.33			2.41

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars. Empty cars which are reckoned as one loaded car are not given upon all of the official reports, from which the above table is compiled. The Union and the Southern Pacific rate two empties as one loaded; the Kansas City, St. Joseph & Council Bluffs and Hannibal & St. Joseph Railroads rate three empties as two loaded; and the Missouri Pacific and the Wabash Railroads rate five empties as three loaded, so the average may be taken as practically two empties to one loaded.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

Poughkeepsie, N. Y., October 4.—A caboose of a freight train jumped the track on the New York Central & Hudson River Railroad near Hyde Park to-night. The engine of an approaching express struck it and was derailed, going into the river. The engineer went down with the engine, but escaped with a few slight injuries. The fireman jumped and was also slightly injured.

St. Mary's, Ky., October 6.—A rear-end collision occurred at Gethsemane, 20 miles north of this city, on the Louisville & Nashville Railroad about 5 o'clock to-day, in which Engineer Higgins and his fireman were instantly killed.

Kansas City, Neb., October 6.—A disastrous collision occurred on the Rock Island Railroad, 9 miles west of Manhattan, shortly before 12 o'clock to-night. The trains were running at a high speed at the time. Engineer Gene Cole was badly scalded and bruised about the face and body. His left arm and two fingers were broken. The engineer of the freight train and fireman Dave Hartington, of the passenger train, were also injured.

Louisville, Ky., October 6.—A rear-end collision occurred on the Knoxville Division of the Louisville & Nashville Railroad at 5 o'clock this morning. The first section of a freight train broke in three pieces, and the cab stopped on the New Hope Bridge. In this Alexander Burke, an engineer in charge of two dead engines, was sleeping. The second section came along striking the caboose on the bridge and carrying it down with it. Engineer Higgins, of the second section, and Engineer Burke, in the caboose, went down with the wreck and are buried beneath the *débris*.

Allentown, Pa., October 6.—A Lehigh Valley express train ran into the rear of a Pennsylvania coal train on the Pennsylvania Road below New Boston to-day. The caboose and three coal cars were knocked over the embankment, and the engineer slightly injured.

Elmira, N. Y., October 6.—A rear-end collision occurred between an engine running wild and a freight train on the Delaware, Lackawanna & Western Railroad this morning between this point and Bath. The engineer and fireman jumped and were bruised about the face and head. The cause of the accident was foggy weather and failure of the flagman to get back the proper distance.

Clay Center, Kan., October 7.—A collision occurred 125 miles west of Kansas City at Keats, on the Rock Island Railroad, to-day, between a freight and passenger train. The engineer and fireman of the passenger train were badly hurt. The cause of the collision was the failure to deliver orders

Reading, Pa., October 8.—A freight train ran into a derailed car that had been thrown off from the opposite track near Exeter Station this morning. The locomotive was thrown down an embankment and fell on its side. The engineer, William Flannery, was seriously scalded.

Alliance, O., October 9.—Two hundred kegs of powder exploded on an east-bound freight train on the Pittsburgh, Fort Wayne & Chicago Railroad near North Lawrence this evening. Engineer Colgan and his fireman were fatally burned.

Leavenworth, Kan., October 9.—John Cookston, fireman on the Kansas City, Wyandotte & Northwestern Railroad, was severely injured this morning by being caught between a crane of a water tank and the tender. He was standing on the step-board outside of the engine.

Boston, Mass., October 10.—Joseph Elbor, fireman on the Old Colony Railroad, was run over by an engine near Jamaica Plains to-day. He left the cab and attempted to drop to the ground, but was caught between the sleepers which cross Stony Bridge, and was dragged a distance of nearly 50 ft. when the wheels of the tender ran over one leg. The other leg and arm were crushed in an attempt to save himself.

Fairfield, Pa., October 10.—A collision occurred on the Beech Creek Railroad near Phillipsburg this morning. Clarence Bradon, engineer of the freight, was hurt about the legs.

Whiting, Ind., October 10.—A Pennsylvania train ran into an open switch and against two Pullman cars standing on the track. Engineer Henry Warner and Fireman John Christy were killed. The fireman was beneath the engine, and was scalded to death by escaping steam.

White River Junction, Vt., October 10.—A through train on the Passumpsic Division of the Boston & Maine Railroad ran off the track just west of the Connecticut River bridge near this station to-night. The accident was caused by a switch being misplaced by an intoxicated switchman. Engineer Rooney was badly hurt by jumping from his engine.

Saginaw, Mich., October 11.—A south-bound express on the Michigan Central Railway ran into a freight train at Chesaning. The engine, tender, baggage and express cars were thrown from the track and badly wrecked. The engineer was hurt.

Wheeling, W. Va., October 11.—A collision occurred on the Wheeling & Lake Erie Railroad near Valley Junction today. Engineer Mears was slightly hurt by jumping.

Norristown, Pa., October 12.—Jacob Raise, engineer on the North Penn Branch of the Philadelphia & Reading Railroad, was struck on the head by a mail crane as he was leaning out of the engine to-night. He was knocked senseless by the blow, but after the train had been stopped at Sellersville by the fireman he recovered consciousness and resumed work.

Troy, N. Y., October 12.—William H. Frame, an engineer on the New York Central & Hudson River Railroad, fell from his engine to the bottom of the turn-table pit at the Green Street round-house this afternoon. He was rendered unconscious by the fall.

Bourbon, Ind., October 13.—There was a rear-end collision on the Pennsylvania Line between two light engines 5 miles west of here to-day. The first was being held for orders when the second ran into it. Engineer Parrish jumped from the engine. He broke his jaw and put out one eye by striking it against a tie.

Jackson, Mich., October 13.—An excursion train running at a high rate of speed dashed into another train at this station this morning. William Whalen, engineer, was badly burned, and one of his legs was broken. He died shortly after from his injuries. The first train was just pulling out of the station and was protected by a semaphore, but it is claimed that the air on the second section failed to work, and the accident was the result.

Appleton, Wis., October 13.—Three box cars loaded with wood ran off a side track near Appleton Junction to-night. A special passenger train ran into them, the engineer being struck on the head by a piece of flying wood and badly injured. Three box cars and several passenger coaches were demolished.

Cumberland, Md., October 13.—A passenger train on the Baltimore & Ohio Railroad ran into a land slide near Sleepy Creek to-night. Charles Pennel, the fireman, was thrown from the cab down an embankment about 40 ft., sustaining injuries about the body and head, and was injured internally. Engineer Dyche was caught in the engine when overturned, but managed to creep out on the foot-board, not, however, until he was scalded by escaping steam.

Buffalo, N. Y., October 14.—A passenger train on the New York, Chicago & St. Louis Railroad collided with eight coal cars, which had been blown off the siding at Athol Springs, a short distance from here this morning. It was storming at the time, and the engineer could not see the cars until he was upon them. Jerry Lane, the fireman, was caught in the engine cab and crushed to death. Henry, the engineer, was badly hurt and may not recover.

Chicago, Ill., October 14.—A collision occurred between an engine of the Chicago & Northern Pacific Railroad and a Baltimore & Ohio passenger train at Archer Avenue to-day. Mark Murphy, fireman of the Chicago & Northern Pacific engine, had his head and hip hurt in jumping from the engine. David Ullery, fireman of the Baltimore & Ohio engine, was also bruised in jumping.

Topeka, Kan., October 15.—A collision occurred near Paxeco, 20 miles west of here, this morning between a freight and passenger train. Charles Topham, engineer of the passenger train, jumped and sustained fractures of the skull, from which he subsequently died.

Pittsburgh, Pa., October 17.—During a fog this morning the Pennsylvania Limited ran into some cars at Wellsville, O., which resulted in the death of the entire engine crew, which consisted of Elmer Jackson, fireman, John Carrolhois, a pilot, and Robert Jackson, the engineer.

Bath, N. Y., October 17.—A Delaware, Lackawanna & Western passenger locomotive fell over into the turn-table at this place this morning. Engineer James Clarke was badly injured.

Port Arthur, Ont., October 17.—A wreck occurred this morning on the Canadian Pacific Railroad near Grand River. A special train of cars collided with a freight train. Fireman Wilbridge was killed.

Lynn, Mass., October 19.—Walter S. Clarke, a fireman, fell from his train near Oak Island this evening, and was very seriously injured. It is thought that a blood-vessel of the brain is ruptured. He has been unconscious since being taken to the hospital.

Weigold, N. Y., October 19.—An Erie freight train was struck by a Syracuse & Oswego express at this point this morning. Engineer William Worrell, of the Syracuse train, jumped from his engine and badly sprained his left ankle.

Bavaria, Kan., October 19.—A freight train on the Union Pacific Railroad ran off the track here at midnight. Engineer Frank Schuyler was killed.

Evansville, Ind., October 20.—A Louisville, Evansville &

St. Louis passenger train ran through an open switch to Boonville to-night, wrecking an engine and several coaches. The fireman had his shoulder-blade broken.

Reading, Pa., October 20.—A passenger train on the Pennsylvania Railroad crushed into the rear end of a coal train at Seyfert's Station this morning. Frank J. Lewis, the fireman, was badly hurt.

Battle Creek, Mich., October 20.—A disastrous collision occurred on the Grand Trunk Railroad at this point early this morning. The engineer and fireman of the Pacific express, which ran into a Raymond & Whitcomb special train, jumped and escaped with slight injuries.

Binghamton, N. Y., October 20.—Patrick Neville, a fireman on the Erie Railroad, fell from his engine at Waverly to-day, receiving bad but not serious injuries, the chief of which was a severely sprained ankle.

Perth Amboy, N. J., October 22.—A collision occurred this afternoon in the Tottenville yard of the Staten Island Rapid Transit Railroad, in which Charles Bedell, fireman, was so severely injured that he may die from the effects. The accident was caused by a misplaced switch.

Pittsburgh, Pa., October 22.—A collision occurred between the Columbian express and an east-bound passenger train on the Pittsburgh, Fort Wayne & Chicago Railroad at Monroeville, Ind., this morning. Fireman Daley sustained severe internal injuries, and Engineer R. Cowan was badly scalded.

Birmingham, Ala., October 22.—A Georgia Central engine hauling a passenger train exploded its boiler 5 miles from this point this morning. Engineer Mills and Fireman J. W. Buchanan were killed instantly.

Chillicothe, O., October 23.—A locomotive hauling an express train on the Cincinnati, Hamilton & Dayton Railroad exploded its boiler near Raysville. Engineer F. M. Arnold and the fireman, F. Shields, escaped with a few cuts and bruises.

Trenton, N. J., October 25.—The second section of the Pennsylvania & Chicago Limited, on the Pennsylvania Railroad, ran into a freight train this afternoon at Bear Swamp, 3 miles east of this city. The freight had jumped the Pennsylvania track, and before the latter could be stopped the collision occurred. Engineer David Mahoney and Mathews, fireman of the Limited, were badly injured.

Batavia, N. Y., October 25.—William B. Nichols, a passenger engineer on the New York Central & Hudson River Railroad, was struck by a mail catcher standing alongside the track as he was leaning out of his cab window at this point to-day. He fell back to the floor of the cab unconscious. His skull was fractured.

Toledo, O., October 25.—A north-bound freight on the Toledo, Ann Arbor & North Michigan Railway ran into a sink-hole 3 miles north of Hamburg Junction this evening. The engineer, Beaulieu, and Fireman Alberts were caught in the cab and burned to death before help could reach them.

Portage, Wis., October 26.—E. R. Crippen, an engineer on the Chicago, Milwaukee & St. Paul Railroad, was struck by a switching engine at this point to-day. Three ribs were broken, and he was badly bruised.

Salt Lake City, Utah, October 26.—A freight train on the Utah Central Railroad was derailed by spreading of rails near this city to-day. The engine was overturned, and steam and water belched forth from the boiler, severely scalding E. M. Heywood, the engineer.

Elizabeth, N. J., October 27.—A defect in some part of the boiler of a locomotive on the Central Railroad of New Jersey caused a blowing out of the steam and water at this point to-night. Engineer W. T. Taylor was severely scalded about the face, neck, and hands.

Worcester, Mass., October 27.—Harry Blaisdell, a fireman on the Worcester Division of the Consolidated Railroad, was struck square in the face by a heavy wooden joist protruding from a freight train, which stood on the siding near Woonsocket to-night. His face was fearfully mangled, and one side of the jaw-bone was splintered.

Newburg, N. Y., October 27.—Engineer Compton, of the New York, Lake Erie & Western Railroad, was leaning out of his cab window to discover the noise of a rattling under his engine, when he was struck on the head by a signal pole and knocked to the ground. His injuries were not of a serious nature.

Florence, S. C., October 27.—The Coast Line Fast Mail was wrecked at Salem early this morning. The switch lock was broken off and the switch set for the side track. The weather was very foggy, and the engineer did not see the danger until he turned into the switch. Engineer Joseph J. Jennings stuck to his post, and was bruised about the head and scalded about the leg. Fireman Gen. Burnett was bruised about the body.

Kenosha, Wis., October 28.—A passenger train on the Kenosha Division of the Chicago & Northwestern Railroad was thrown from the track by the pilot of the engine dropping down. The engineer, William Stewart, was scalded so badly that he died later this evening.

Somersville, S. C., October 30.—The New York fast freight, on the South Carolina Railway, ran into a cow three-quarters of a mile west of Jedburg to-night. The engine was completely turned around, and the 15 cars composing the train were all derailed. John S. Whaley, the engineer, was killed, and the fireman, named Holslander, was badly bruised.

Parkersburg, W. Va., October 30.—A passenger train on the Baltimore & Ohio Railroad ran into the rear end of a freight train near Chestnut Hill this evening. Fireman Kearnes was hurt, but not seriously.

South Meriden, Conn., October 30.—A passenger train on the New York & New England Railroad ran into a box car on the siding at this point this evening. The cause was a misplaced switch. The engineer, Baker, was thrown from his cab through a trestle to the ground about 20 ft. below, but was not seriously injured.

Newcastle, Pa., October 30.—Two engines were in collision on the Pennsylvania Line near Mahoningtown this evening. Lewis Styne, the fireman, and Jacob McLean, the engineer, were badly injured.

Norfolk, Va., October 31.—A collision due to an open switch occurred on the Lambert's Point Division of the Norfolk & Western Railroad this morning. The fireman and engineer were both killed.

Norwalk, O., October 31.—E. B. Squire, fireman on the Wheeling & Lake Erie Railroad, was severely injured at Massillon, by falling from his engine and striking his back and hips.

Rochester, N. Y., October 31.—The fire of an engine of a freight train on the New York Central & Hudson River Railroad burst through the furnace door near Cartersville to-day, burning Engineer Siener and Fireman Kemp very severely. The accident is said to have been caused by the netting on the smoke stack becoming clogged.

Honesdale, Pa., October 31.—Two coal trains on the New York, Lake Erie & Western Railroad collided near Rowland Station this evening. Peter Haddock, the fireman, was killed.

Our report for October, it will be seen, includes 62 accidents, in which 15 engineers and 13 firemen were killed, and 35 engineers and 23 firemen were injured. The causes of the accidents may be classified as follows:

Blowing back of fire	1
Boiler explosion	2
Bursting of steam pipe	3
Collision	25
Derailment	7
Fell from engine	4
Land slide	2
Misplaced switch	7
Powder explosion	1
Spreading of rails	1
Struck by obstruction	4
Struck by train	4
Struck cow	1
	62

REPORTS OF DETENTIONS AND DEFECTS OF LOCOMOTIVES.

The tabular Summary of Reports of Detentions to Trains from Defective Machinery on one of our prominent lines, which we published last month, has attracted a considerable amount of attention from locomotive superintendents and others in responsible places on some of our railroads. Naturally some inquiry has followed with reference to the methods of collecting and keeping such reports. We therefore give herewith the form of blank which is used on the New York Central Road for reporting detentions and the causes of them. These are sent to the general office and are there recorded and tabulated. On those roads where such reports have been kept, and have then been systematically arranged, it has been found that a flood of light has been thrown on the nature of the defects of machinery which cause detentions, some of which, before such investigations have been started, have not been suspected or their extent and significance has not been understood. The primary cause of a large proportion of accidents is a detention. Reduce the number of these, and it is as certain as mathematics that the number of accidents will be diminished. It is believed that there is no direction in which railroad managers could make investigations, which would be

so fruitful of good results, as a careful compilation of reports of the causes of detentions, such as we have given in the table referred to, would be.

The following is the blank used on the New York Central Railroad:

NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

HARLEM DIVISION.

Engineer's Train Report..*Division.*

Train No .... *Date*....................................

Engine No.............. *Number of Cars*..........................

Leaving Time Card.................... *Actual Time*....................

Arriving Time Card.................... *Actual Time*....................

Engineer.................................. *Time Lost*....................

Fireman..

CAUSE OF DETENTION, ETC.:

....

....

....

It has also been found on the New York Central Railroad, and doubtless on other lines as well, that many of the men have an aversion to or apprehension of making a written report. They do not know how to express themselves correctly, and are afraid of revealing their ignorance in some way. They have not the same feeling about assenting or dissenting to or from any question relating to their locomotives or their duties. Acting upon this general idea, Mr. Buchanan has prepared a list of inquiries relating to the condition of the brake equipment on the engines on his road, and which merely require an × mark to indicate the condition of the part, or whether it performs its function properly. It is found that the men will report more willingly and fully if a blank of this kind is provided, than they would if required of their own volition to say what is wrong and what parts are in good condition. It has besides the advantage, which all catechisms have, that the question suggests an investigation into the condition of the part inquired about. If an engineer is asked whether the "throttle-valve of his air pump needs grinding," or whether "the brake-valve handle moves too hard," he will be more apt to find out whether such defects exist or not than he would be if they were not suggested by the question. His answer is readily given by making his × mark or omitting it. Those of us who were born with the alphabet on our lips, and into whose hands a pen was put almost as soon as we could grasp it, have little idea what a formidable matter it is for a person who has little familiarity with the three cardinal R's to express himself in writing.

We believe we are stating an exact fact in saying that there are many locomotive engineers who would rather encounter a collision on the road than to write a report of one. To such men a blank like the following for reporting the defects of their air-brakes is a great boon, and it is also an advantage to those who should have the fullest information concerning the condition of this part of the equipment of the roads for whose successful operation they are responsible.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD COMPANY.

OFFICE OF THE SUPERINTENDENT OF MOTIVE POWER AND ROLLING STOCK.

October 1st, 1893.

WM. BUCHANAN, *Superintendent.*

ENGINEER'S DAILY REPORT OF REPAIRS NEEDED TO AIR BRAKE EQUIPMENT ON ENGINE NO.............

To the Despatcher of the Round House at..........................

(Engineer's notation marked thus:—"X." Inspector's notation marked thus:—"O. K.") in column as shown.

	×	O. K.
Pump will not work		
Pump will not compress air fast enough		
Pump does not get oil enough		
Throttle valve needs grinding		
Regulator needs to be adjusted		
Regulator requires too great a reduction of air		
Engineer's brake valve, handle moves too hard		
Engineer's brake valve, rotary valve leaks		
Engineer's brake valve, piston valve leaks		
Engineer's brake valve, feed valve leaks		
Engineer's brake valve, handle spring is weak or broken		
Engineer's brake vale, reserve pressure is not right		
Piston travel, tender brake cylinder		
Piston travel, driver brake cylinder		
Main reservoir needs draining		
Auxiliary reservoir on engine needs draining		
Auxiliary reservoir on tender needs draining		
Train pipe drain cup needs draining		
Triple valve needs draining		
Triple valve needs		
Leaks, driver brake leaks off		
" tender brake leaks off		
" in brake pipe—train line		
" between pump and engineer's valve		
Hose, defective at front end of engine		
" defective at rear end of tender		
" between engine and tender, defective		
New shoes, on driver brake		
" on tender brake		
Brake cut out on engine account of		
Brake cut out on tender account of		
Air signal out of order		
Miscellaneous		

Engineer.................................. *Date*....................189

Inspected and repaired by.............................*Inspector.*

Date.............................189

NOTE.—Date, Name, Number, etc., must be shown when report is made, by both Engineer and Inspector, and the Inspector will be required to make a daily inspection of each engine, whether reported or not, and if any defects are found, not noted on report, the same must be repaired and marked O. K. in Inspector's column.

ENGINEERING SOCIETIES OF AMERICA.

(Compiled from a Table prepared by Professor J. B. Johnson, of St. Louis, December 21, 1892.)

Name of Society.	Date of Organization.	Total Membership all Grades.	Entrance Fee.	Annual Dues.	Number of Meetings Yearly.
National.					
American Society of Civil Engineers.....	1852	1,543	$30 00	$25 00 / 15 00	20
American Institute of Mining Engineers.	1871	2,398	10 00	10 [illegible]	3
American Soc. of Mechanical Engineers.	1881	1,582	25 00	15 00	2
American Inst. of Electrical Engineers...	1884	643	5 00	10 00	10
Total.......	...	6,136			
Local or Sectional.					
Boston Society of Civil Engineers........	1848	302	10 00	6 00 / 4 00	11
Engineers' Club of St. Louis............	1869	180	10 00	10 00 / 5 00	18
Western Society of Engineers............	1869	478	5 00	10 00 / 7 50	[illegible]
Engineers' Club of Philadelphia.	1877	458	5 00	10 00 / 5 00	..
Civil Engineers' Club of Cleveland.......	1880	155	5 00	8 00	12
Engineers' Society of W. Pennsylvania..	1880	420	5 00	7 00 / 5 00	20
Denver Society of Civil Engineers........	1882	70	10 00	12 00 / 8 00	25
Engineers' Society of St. Paul...........	1883	45	5 00	4 00	8
Engineers' Club of Minneapolis...........	1884	30	5 00	5 00	10
Technical Society of Pacific Coast.... ..	1884	250	5 00	12 00 / 6 00	12
Canadian Society of Civil Engineers....	1887	688	10 00	8 00 / 6 00	16
Montana Society of Civil Engineers......	1887	54	5 00	10 00	12
Engineers' Club of Kansas City..........	..	49	5 00	8 00	9
Engineers' Club of Cincinnati...........	1888	128	1 00	5 00 / 3 00	[illegible]
Engineering Association of the South...	1889	122	5 00	8 00 / 5 00	[illegible]
Wisconsin Polytechnic Society	1890	43	5 00	10 00	10
Engineers' and Architects' Club, Louisville, Ky.......	1891	74	10 00	18 00	[illegible]
Total.......	...	3,491			

—*Trans. Am. Inst. Electrical Engineers.*

GENERAL MARINE NOTES.

A Ship Canal Project.—Town Council of Bruges, in Belgium, has resolved to subsidize a company to the extent of 3,000,000 francs for the construction of a ship canal to connect the city with the sea. The object is to restore Bruges to her old-time commercial importance and make her a rival to Antwerp, Ghent, and other cities in the low countries having similar artificial waterways.

The French Warship "Jurequibberrer."—This vessel, which was recently launched at Toulon, is a steel turret ship of 11,830 tons displacement. She is 356 ft. long, 72 ft. 8 in. beam, with a main draft of 27 ft. Her engines will be of 13,275 H.P., and her armament will consist of two 11¾ in., two 10¾ in., eight 5½ quick-firing, and eight machine guns.

The Telephone for Diving Purposes.—The telephone is now used by deep-water divers. A receiver and transmitter combined is affixed to the inside of the helmet near the diver's ear. By a slight turn of the head he can speak into the 'phone, and he can hear readily from it at all times. Its value in deep sea work, for reporting progress or receiving instructions, is clear. Formerly the only communication was by a system of pulls at a cord.

Electric Lights in Shore Defenses.—An interesting sham night attack was recently devised and carried out at Portsmouth, England. Besides the primary object, which was to determine how far the electric lights of shore defenses is efficient for the lighting up of vessels attempting to approach the harbor, the affair had something of the nature of a surprise, and was intended to test the mobilization scheme for the defense of the eastern entrance to Spithead. As far as observation went, the electric lights appeared too feeble for the purpose contemplated.

Test of Defense Nets.—The Ericsson submarine gun, the Destroyer, which was illustrated in our issue of May last, was tried against a heavy torpedo net at Newport, R. I., the latter part of October. The net tried was a nickle-steel American net that is in competition with the English net. The range and charge were the same, 200 ft. and 15 lbs. The heavier net was as easily and clearly cut through as the lighter American net had previously been done by the projectile. The shot was as true to its aim as it could possibly have been.

A Powerful Electric Lighthouse.—The electric lighthouse at the Cape of La Heve, about 3 miles from Havre, with an illuminating power of 23,000,000 candles, has been described and illustrated by the foreign technical press as the most powerful lighthouse in the world, but the engineer-in-chief of the French Lighthouse Service has now completed plans for a new lighthouse, of which the illuminating intensity will be equal to 46,000,000 candles. Its light will be sent 248 kilometers in clear weather, 100 kilometers in average weather, and 40 kilometers in foggy weather. This light will be located at Penmarck, a headland projecting into the Atlantic in the Department of Finistere.

Copper Plating Ships' Bottoms.—A new process of copper plating the bottom of war and other vessels has recently been brought out. It consists of dropping a sort of air-tight tank down the side of the vessel and copper plating the sides in sections, the intention being to overcome the difficulty and expense of dry-docking vessels of war. It is claimed that the whole of the bottom of a war vessel drawing 20 ft. of water can be plated from the water-line down complete in eight or nine days by using 60 baths at once on each side, with 780 H.P. shifting the baths two or three times. The plated surface would aggregate about 24,000 sq. ft., the estimated cost of which would be $6,660.

Battleship "Oregon."—The battleship *Oregon* was launched from the yards of the Union Iron Works, in San Francisco, on October 26. When she is completed and equipped her displacement will be 10,200 tons. Her length is 350 ft. 9 in., with a beam of 69 ft. 3 in., and 24 ft. draft. The armament will consist of four 13-in. breech-loaders, two each in a turret at either end. Their mounting is similar to that of Big Betsey and Alice on the *Monterey*, but they are larger in caliber by 1 in. There are also eight 8-in. breech-loaders and four 6-in. breech loaders located in sponsons. The secondary battery consists of 20 rapid-fire 6 pdr. and eight rapid-fire 1-pdr., four Hotchkiss rifled cannon, and six torpedo tubes. The midship section is covered with 18-in. armor.

Electric Lighting of the Bosphorus.—A plan has been proposed at Constantinople for lighting that city with electricity, and the whole of the Bosphorus from Cavak as far as San Stefano, upon the Sea of Marmora, by means of three powerful machines to be erected on three points of the Bosphorus where the current has an extraordinary force—that is to say, at Arnaout-Keui, Candilly, and at Serai-Bournou, at the entry of the coast port of the Sea of Marmora. The project has appeared to be so practical and realizable that a company of capitalists has been formed, the necessary funds subscribed, and a demand of a concession has been addressed to the Turkish Government. The latter, on the other hand, has taken the project into serious consideration, and, without losing time, has nominated a commission *ad hoc* to examine the details, and draw up an official detailed report.

Ship on Rollers.—Some of the English and French papers have recently been illustrating a proposed form of Atlantic greyhound, in which the vessel stands on eight rollers. It is designed by M. Bazin, who was the inventor of the Bazin dredge. It is proposed to construct an Atlantic liner on eight rollers, on the theory that these rollers will give far less resistance to the waves than the present form of steamship construction, and that, therefore, a higher speed may be developed, estimated at 30 knots per hour, from Southampton or Liverpool to New York. It is proposed to put the plan to a practical test by constructing a vessel of about 400 ft. in length by 100 ft. beam, with rollers 80 ft. in diameter. It is estimated that these will make 22 revolutions per minute, and that 10,000 H.P. will be required. It is hardly probable, however, that we are on the verge of a revolution in marine construction.

Bids for War Vessels.—The bids which were recently opened by the Navy Department for the construction of three light draft gun-boats of about 1,200 tons displacement each cover an appropriation in which the construction is limited to $400,000. The boats are to be designated as gunboats No. 7, 8 and 9 respectively. No. 7 is a flush-decked schooner-rigged steel gun-boat, not sheathed, with double bottom and close water-tight subdivisions at the water-line. Her length of water-line with normal displacement is to be 220 ft., and the

maximum breadth molded 36 ft. An average speed of 14 knots per hour for four consecutive hours will be required. Gun-boats Nos. 7 and 9 have been designed for a special purpose in rivers and shallow waters of China. Their length with normal displacement is 256 ft. 6 in., with a maximum breadth molded line of 40 ft. The lowest bid was from the Newport News Ship & Engine Building Company, for all three boats $280,000 each, or $290,000 for No. 7.

Double Gun Carriage.—A new form of gun carriage has recently been tested at the Naval Ordnance Proving Ground at Indian Head. Two guns have been mounted on a single carriage which is capable of turning the weapons together with one mechanism. The guns were 4-in. caliber, and were fired under all possible conditions. The results were eminently satisfactory, but the Ordnance Board is in doubt as to whether the advantages of the arrangement will offset the disadvantages. On the one side, the system has to commend it the lighter weight of two guns on one mount and the ability of having two projectiles where ordinarily but one would be delivered. Against these conditions is the liability of disabling two guns instead of one, for damage to the carriage would mean putting out of battle two weapons. The present carriage will probably be mounted on the forecastle or poop-deck of one of the ships of war. It is not likely, however, that the system will be extended to the Navy generally.

A Curious Railway.—Spain has a novelty in the way of a submerged railway. It runs through the surf at Oreton, near Bilboa, 650 ft. out into the ocean. The mines of Oreton are extremely rich in iron, but there is no harbor there, and great difficulty has hitherto been experienced in getting the ore to the ships. Now that the submerged railway has been built, it is a simple matter. It runs out into deep water, and an iron tower, 70 ft. high, worked by counterbalances, runs from the cliffs to the waiting vessels, which are moored, bow and stern, in the roadstead. When the tower arrives at the ship, its top, bearing the load of ore, is about level with the vessel's deck. As soon as the iron is loaded on the ship the weight of the counterbalances pulls the tower back to the cliff, where it runs up to a chute, and automatically opens its mouth. The chute comes down from the mines, and, when it has dropped on the tower enough ore to overcome the weight of the counterpoise, the tower starts away to sea again. This movement is kept up until the vessel is filled. All that is necessary to do to start the tower on its peregrinations and put the submarine railway in operation is for the miners to drop ore into the chute.—*Montreal Witness.*

Electric Hoists for Whalebacks.—A new departure is promised in connection with the proposed new ore docks for the whalebacks at Conneaut, O. Permanent bridges will span slips 100 ft. wide for the operation of electric hoisting machines. These bridges will be high enough to clear the decks of the whaleback barges by 30 ft. The design is for the steamers, which will tow two consorts each, to put her barges far into these great slips, and then to follow head in, the three passing under the trestle bridges, except that the stern of the steamer, with her stack, will be outside the outer trestle. The cars will then run directly over the hatches, dumping the ore on either side of the slip. After the power house is supplied with men, the electric hoists require only one man to a car. He travels with the bucket, and dispenses with the signal men and extra engineers and firemen required by the steam hoists The same power that propels the machinery generates light, so that the stock piles and the holds of the boats can be illuminated and the work carried on by night as well as by day.—*Evening Wisconsin.*

The Most Suitable Coal for Use on War Ships.—It has been shown that the true practical value of coals for steam purposes depends upon a combination of qualities which could only be elicited by carefully and properly continued experiments. These qualities, so far as regards steamships of war, are referred to as follows :

1. The fuel should burn so that steam may be raised in a short period, if this be desired ; in other words, it should be able to produce a quick action.
2. It should possess high evaporative power—that is, be capable of converting much water into steam, with a small consumption of coal.
3. It should not be bituminous, lest so much smoke be generated as to betray the positions of ships of war when it is desirable that this should be concealed.
4. It should possess considerable cohesion of its particles, so that it may not be broken into small fragments by the constant attrition which it may experience in the vessel.
5. It should combine a considerable density, with such mechanical structure that it may easily be stowed away in a small space ; a condition which in coals of equal evaporative values often involves a difference of more than 20 per cent.—*Coal Trade Journal.*

Trial of the "Columbia."—The official trip of the cruiser *Columbia* was held off the coast of Massachusetts on November 18, where the remarkable speed, at one point of the run, of 25.31 knots was attained, giving an average speed of 22.81 knots over a course of 82.82 nautical miles. Inasmuch as her contract speed was 21 knots, with a premium of $50,000 for each quarter knot in excess, it is probable that when the official records are published, it will be seen that the Messrs. Cramp will be allowed a bonus for seven quarter knots in excess, or $350,000. The maximum revolutions of her propellers was about 138 on the port and starboard engines, and 132 on the after engines. Her average steam pressure was 155 lbs. to the square inch, developing 21,500 H.P., and burning about 30 tons of picked Pocahontas coal an hour while running over the course. The vessel was run under a forced draft on the closed fire-room principle, the crew in the engine-room consisting of 264 men. The *Columbia* thus becomes the swiftest sea-going vessel afloat, the nearest approach to her in point of speed being the warship *Neuve de Julio*, owned by the Argentine Republic, which was built by the Armstrongs. Her greatest speed was 22.74 knots. The differences in the tests, however, are very greatly in favor of the *Columbia*, inasmuch as she ran for nearly 100 miles without any slowing down, while the *Neuve de Julio* ran for only 22 miles. It is probable that, were the same rules to govern trials in this country as obtained abroad, the *Columbia* would be rated as a 25-knot ship, for she attained more than this speed over an 8-mile stretch. The requirements, however, in this country are higher than elsewhere. The arrangements of the engines and boilers in the *Columbia* are practically the same as those of the *Minneapolis*, which were illustrated in our issue of September of this year.

Spanish Cruiser "Infanta Maria Teresa."—The latest addition to the Spanish Navy is one of a class of cruisers, for the construction of which the Government four years ago granted an extraordinary credit of about $50,000,000. It was built in Spain at a shipyard and engine building shop of which the country is very proud, although it was created almost entirely by English influence, imported its machinery from England, from which country also it still draws its chief workmen. The *Infanta Maria Teresa* is built entirely of Siemens-Martin steel. It is 340 ft. long between perpendiculars, 364 ft. over all, 65 ft. breadth of beam, 28 ft. deep, and of 7,000 tons displacement on a draft of 21 ft. 6 in. It has a ram bow and two military masts, with signaling yard crossed on each. For 315 ft. amidships the vessel has a 12-in. cammell steel armor belt 5 ft. 6 in. broad, backed by 6 in. of teak. The ship has eight torpedo tubes. The principal armament includes two 28-cm. guns mounted in barbette turrets, ten 14-cm. guns, two 7-cm. guns, eight 57-mm. Nordenfeldts, two 11-mm. Nordenfeldts, and eight Hotchkiss. The propelling engines are of the vertical triple-expansion surface-condensing direct-acting type, driving twin screws, and are designed to develop collectively about 13,500 indicated H.P. with forced draft, the contract speed for which is 20 knots. The cylinders are 42.62 and 92 in. diameter by 46 in. stroke. There are over 50 separate and auxiliary engines in the vessel. The propellers are three-bladed, of bronze 16 ft. 5 in. in diameter and 20 ft. 6 in. pitch. Steam is supplied by four double-ended boilers 16 ft. 3 in. in diameter, and two single-ended boilers 15 ft. 3 in. long by 10 ft. 6 in. in diameter, working at a pressure of 150 lbs. to the square inch; the test pressure being 250 lbs. The grate surface is 845 sq. ft. ; tube surface, 22,270 sq. ft. ; total heating surface, 25,920 sq. ft.

Police Boat for New York Harbor.—There is being built at the yards of the Marine Department of the Maryland Steel Company, at Sparrow's Point, near Baltimore, a twin-screw steel steamer for the Police Department of this city. This vessel will be named *Patrol*, and will be used for police work in and around the harbor of New York.

The dimensions of the boat are :

Length over all	143 ft. 6 in.
" between perpendiculars	135 "
Beam	23 "
Depth amidships	10 " 6 "
Draft of water, forward	6 "
" " " aft	8 "

The material used is all mild steel, the plating being put on in six in and out strakes, averaging about 15 lbs. per square foot. The bar keel is 6 in. × 1¼ in., and stem is 6 in. × 1¼ in. The stern-post is of cast steel 6 in. × 3 in. at the top, tapering to 1½ in. at heel. The frames are angles 3 in. × 2½ in., spaced

21 in. between centers. The reverse frames are 2½ in. × 2½ in. The bilge, keelson, and hold stringer are double angles 3 in. × 2½ in. Forward at the water-line the plating is doubled as a protection against ice.

The engines consist of two compound surface-condensing, inverted direct-acting, operating twin screws 6 ft. in diameter by 9 ft. pitch. The cylinders are 13 in. and 24 in. respectively for the high and low-pressure by 18 in. stroke. The air-pumps are worked by low-pressure cross-heads. The circulating pumps are of the centrifugal type worked by independent engines. The main engines are reversed by steam, and so arranged that one man can control both of them.

The high-pressure cylinders are equipped with a piston-valve, and the low-pressure with a double ported slide-valve of the Trick pattern. Steam of 120 lbs. pressure will be furnished by two boilers of the gunboat type 17 ft. 6 in. long × 7 ft. 9 in. diameter. Thickness of shell, ½ in.; heads, ½ in. Each boiler has two corrugated furnaces 36 in. diameter × 7 ft. 6 in. long, and seventy-eight 3 in. tubes and seventy 3½ in. tubes. The engines and boilers are so piped as to guard against total disability in case of ordinary accident. The main engines are expected to develop 500 indicated H.P., and should drive the boat at about 16 statute miles per hour.

There is a large deck-house arranged on the main deck. At the forward end there is a handsome saloon containing the main companion-way. This saloon is finished in ash. Abaft this saloon are the mess-room for the crew, pantries, store-room, and a large galley. The upper engine-room is finished in red oak and white bass, and abaft the engine-room is a large ladies' saloon finished in butternut. Opening off this saloon are two state-rooms with a toilet-room. On the top of the deck-house is a pilot-house and a smoking-room, both finished in mahogany. On the berth deck forward is the forecastle, and separated from this by a bulkhead is the main dining saloon, about 12 ft. × 20 ft. On each side of the companion-way leading to this saloon are two large double state-rooms for guests and four single ones for the captain, mate, chief engineer, and first assistant.

The boat is handsomely furnished throughout, and will make a noteworthy addition to the fleet of New York Harbor. The boat is divided by four water-tight bulkheads, and is equipped with a steam steering-gear and a complete electric lighting system, including a 4,000-candle power search light.

There is also a Worthington duplex fire-pump 14 × 9½ × 10, designed expressly for this boat, which can be used as a wrecking pump when desired. It has a capacity of 48,000 galls. of water per hour. There are two masts 60 ft. long of 12 in. diameter.

The total cost of the boat will be about $55,000, delivered in New York Harbor. This price is very cheap when compared with boats of similar character, and the Police Department is to be congratulated on its purchase.

PROCEEDINGS OF SOCIETIES.

Civil Engineers' Club of Cleveland.—A monthly meeting of this Club was held on October 10, and a paper on the Cam and its Importance in Modern Development of Manufactures read by Mr. F. H. Richards, of Hartford, Conn.

Boston Society of Civil Engineers.—The regular meeting of the Society was held on the evening of November 15. A paper by Arthur W. Hunking was read, entitled Notes on Water Power Equipment and Considerations affecting the Selection of a Turbine.

Place of Meeting of the Master Mechanics' and Car-Builders' Associations Next Year.—The Joint Committee of the two Associations has decided on Saratoga, N. Y., as the place for the next Convention. Mr. R. C. Blackall, of the Delaware & Hudson Canal Company, is Chairman of the Committee of Arrangements; Mr. S. A. Crone, of the New York Central Line, will represent the Car-Builders' Association, and Mr. Thomas Purves, Jr., the Master Mechanics on that committee. Application for rooms should be made to Mr. H. S. Clements, Manager of Congress Hall—where the Associations will meet—for rooms.

American Society of Mechanical Engineers.—The annual meeting of this Society will be held at its house, No. 12 West Thirty-first Street, from December 4–8. The first session will be held on Monday evening, at which Mr. Eckley B. Coxe, the President, will deliver the presidential address, after which there will be a social reunion. The regular business and professional sessions of the meeting will commence on Tuesday morning, and be held in the morning and evening of Tuesday and on the mornings of Wednesday, Thusday, and Friday.

The following is a list of papers which will be read: A. K. Mansfield, The Buckeye Engine Valve Gear; R. H. Thurston, The Maximum Contemporary Economy of the High-pressure Triple-expansion Engine; George A. Morison, Expansion Bearings for Bridge Superstructure; Barton Cruikshank, A Device for Drill-jigs; Frederick A. Scheffler, A Curve Delineator; Frederick W. Taylor, Notes on Belting; R. C. Carpenter, Some Experiments on the Effects of Water Hammer; R. C. Carpenter, Constants for Correcting Indicator Springs which have been Calibrated Cold; W. S. Aldrich, The Use of the Indicator in Dynamometric Testing; R. C. Carpenter, A New Form of Prony Brake; D. S. Jacobus, A Comparison of Mean Effective Pressures of Simultaneous Cards Taken by Different Indicators; H. L. Gantt, Recent Progress in the Manufacture of Steel Castings; William A. Pike, Steam Piping and the Efficiency of Steam Plants; Charles H. Manning, A Method of Manufacture of Large Steam-pipes; James B. Stanwood, Strength of Rim-joints in Fly-band Wheels; R. C. Carpenter, Experimental Determination of the Effect of Water in Steam on the Economy of the Steam-engine; F. A. Scheffler, Test of a Boiler using Grates with a Small Percentage of Openings; William A. Rogers, The Cumulative Errors of a Graduated Scale; William H. Francis, A Modern Disinfecting Plant; W. S. Crane, Crucible Furnace using Petroleum; David Guelbaum, Theory of Direct-acting Steam Pumps.

On Wednesday evening there will be a reception at Sherry's, Thirty-seventh Street and Fifth Avenue.

Engineers' Club of Philadelphia.—At a meeting of the Club on November 18 a paper was read by Mr. Pierre Giron on the Grinding of Portland Cement. He stated that when well-burned Portland cement is fresh from the kiln, it presents itself in the shape of black or greenish-black clinkers of great hardness and density. The agency of powerful machinery is required to bring these clinkers to the state of very fine powder. Even after the most thorough grinding the powder is still gritty, owing to the presence of fine grains which have not been reduced to an impalpable powder. Until a few years ago the fineness of grinding was considered of secondary importance, but lately it has become one of the essential qualities of slow-settling cements.

The first operation consists in breaking up the large lumps of clinkers. For this a jaw-crusher of the Blake type is generally used. The product of this crusher is still too large for the final operation of grinding, and an intermediate process is necessary to further disintegrate the material. This is done in most American cements by a pot-cracker or coffee-mill, but the general use of crushing rolls in other mining industries of the country will eventually lead to their adoption by cement manufacturers.

The final grinding is done almost universally with mill-stones. The stones are of a special quartz formation, and from 4 to 5 ft. in diameter. They weigh over a ton each, and last about a year. The European practice is to run the upper stone at 90 to 120 revolutions per minute, and when working under favorable conditions it may be estimated that an expenditure of 30 to 35 H.P. will give a ton of finished cement per hour. The practice in America is somewhat different. The millstones are smaller, generally not more than 36 in., the upper being stationary, while the lower is driven at a very high speed, sometimes over 300 revolutions. The cost of grinding in this country is greater than in Europe, and the cement is not, as a rule, as finely ground.

The efforts made to supersede the millstones have resulted in the adoption by several cement works in Germany of the Jewish ball-mill. In this country the Griffin mill in its improved form has been adopted by some cement makers. A successful grinding machine should be capable of developing great power, and its mechanical construction should be such as to produce the maximum effect for an unlimited time with the least wear and tear. These conditions imply simplicity and massiveness. The pulverizers of the present day are more or less deficient in these requirements. This circumstance has led the author to take part in the efforts that have been made to solve the problem. His researches have culminated in the construction of the Morel Ball Pulverizer, of which illustrations have been prepared to accompany this paper. The principle of this mill is one in which the grinding is accomplished partly by percussion and partly by pressure. The principal part is a large steel ring having a concavity in its inner side, in which spherical balls are made to fit loosely. These balls, 9 in. in diameter, are four in number, and made of solid forged steel. They are located between the arms of a dividing armature, also made of steel, and set on the vertical

shaft placed in the center of the mill. A circular screen is placed over the ring, allowing the finely ground material to pass through the holes, and rejecting the coarse part under the balls. The material is introduced from an automatic feeder located on the mill itself. The pulverizer complete weighs over 9 tons, of which nearly 5,000 lbs. is specially-treated steel. It is believed to be the largest grinding-machine ever built.

Technical Society of the Pacific Coast.—At a recent meeting of the Society Admiral Selwyn read a paper on the Existing State of the Fluid Fuel Question, in which he stated that he had been engaged in working upon the problem of burning oil since 1867, and that the results which he obtained were certainly very remarkable, in that no change was required in the furnaces, stating that any engineer can pull out his coal grate and put the oil burning furnace in in 48 hours at the most, and it will not take much longer to make the injector and fit the pipes and tank. It can all be pulled out and the boiler be burning coal again in 24 hours.

In making a comparison between oil and coal as a fuel, he states that, owing to the fact that the atoms of the oil are more widely separated than those of coal, less work is required in effecting their union with oxygen, and instead of six units, less than four will be wanted. Owing also to the hydrogen present, the theoretic calorific value will be 21 instead of 16; 21 less four leaves 17 units for evaporative duty instead of 10, and 16 9 lbs. of water were, in 1869, actually evaporated per pound of oil used in experiments with a boiler of 160 nominal H.P., burning heavy oil of lubricating quality, and having a specific gravity greater than salt water. The experiments lasted nine months and were undertaken for the British Admiralty, being under the close supervision of their own engineer the whole time.

There is a most important difference between the blowing in of oil by means of steam as compared with blowing in with air, which is not by any means generally understood. The steam contains hydrogen, and the air does not. One lb. of steam (considered as water) is required to blow in 1 lb. of heavy oil at common pressures, up to 50 or 60 lbs. on the inch, less as that pressure is increased. This has been complained of by some persons, as if it were a heavy tax on the boiler using oil. But as a fact, for which I can vouch, each pound of steam so used produces the full calorific effect due to its hydrogen, and adds to the duty of the oil fuel seven more units of heat, bringing the evaporation up to 22 or 23 lbs. of water (measured from the supply tanks) per pound of oil and steam burned. The hydrogen, finding incandescent carbon in the furnace unites with it to form hydro-carbon, and is then burned with the above useful effect. Roughly, in this manner, there can be obtained three times the evaporative duty of the best steam coal. Now the hydrogen, being a gas, is "fluid," but not "liquid" fuel. Being a gas the loss in dissociation is not more than one unit of heat, and it readily combines oxygen, as we know from the oxy-hydrogen blowpipe, to produce intense heat. We have therefore entered on the use of pure gaseous fuel derived from water, and automatically produced.

At any rate, I have long ago seen it burned, and burned it myself under ordinary marine and Cornish boilers with a result of measured evaporation from oil, hydrogen, and nitrogen together, of no less than 48 lbs. of water per pound of oil used, plus the above gaseous substances, which cost just nothing at all.

This is six times the power of evaporated, "or calorific value," of the best steam coal, and will enable future engineers to drive a steamship round the world, or a railway train across the continent, at full speed, with one supply of fuel weighing no more and occupying less space than a single supply of coal.

I am not yet prepared to give full information as to how the nitrogen is burned, nor as to higher duty than six times coal, which is no doubt possible, but no changes are needed in the furnace, or the injector shown, nor any other which cannot easily be carried out by a ship or railway engineer. All the data I have given are taken from notes made during the actual working, and were checked by civil and naval engineers, to whom my work was always openly shown, is as far as I could be certain of the causes and effects. Of course I drew many inferences, which I am slow to bring forward till everything can be tested and proved to complete demonstration, knowing well how necessary such caution is before asserting a new truth or science, or indeed any departure from long-established practice, however absurd it may become in the light of later discoveries. As far back as 1869 I had not only heard of but carefully examined cases of high evaporation, but I could never find any one who knew what cause to assign it to, till I actually saw in my own furnace the apple-green flame of burning nitrogen, as described by some of the older chemists (who knew well that it was a combustible of great power, though gun-cotton and dynamite had not then been invented), and got 48 lbs. of water evaporated per pound of oil used by the assistance of the hydrogen of the steam and the nitrogen of the air. These latter, then, their nature and their effects have justified. I submit the new nomenclature; I have used "fluid" instead of liquid fuel, for while all liquids and all gases are fluid at our ordinary atmospheric pressure, the gases are not liquids, and such a compound fuel as I have been describing cannot properly be comprised under the term of liquid fuel.

In the discussion that followed it was very evident that the members were somewhat doubtful as to the accuracy of the results which had been obtained, and it was shown that other experiments in oil burning, especially those of the *Solona* and other ferry-boats which were used in San Francisco Bay, did not show the economy and the great advantage which was claimed for burning of oil in these boilers.

PERSONALS.

MR. P. T. LONERGAN has been appointed Master Mechanic of the Rome, Watertown & Ogdensburg Railroad, vice Mr. GEORGE H. HASELTON.

MR. J. T. ODELL, late General Manager of the Baltimore & Ohio Railroad, has been elected Vice-President of the New York & New England Railroad.

MR. JAMES BUCHANAN has been appointed Assistant Superintendent of Motive Power in charge of divisions east of Syracuse on the New York Central & Hudson River Railroad.

MR. E. H. BECKLER, late Chief Engineer of the Pacific extension of the Great Northern Railway, has been elected an honorary member of the Montana Society of Civil Engineers.

MR. GEORGE H. HASELTON has been appointed Assistant Superintendent of Motive Power in charge of divisions west of Syracuse, on the New York Central & Hudson River Railroad, vice Mr. J. D. CAMPBELL, resigned.

MR. R. B. CAMPBELL, General Superintendent of the Trans-Ohio Division of the Baltimore & Ohio Railroad, has been appointed General Manager to succeed Mr. J. T. ODELL, who resigned. This appointment took effect on November 1.

PHINEAS DAVIS.

IN 1831 the Baltimore & Ohio Railroad Company offered a premium of $4,000 "for the most approved engine which shall be delivered for trial upon the road on or before June 1, 1831; and $3,500 for the engine which shall be adjudged the next best." The requirements were as follows:

"The engine, when in operation, must not exceed 3½ tons weight, and must, on a level road, be capable of drawing day by day 15 tons, inclusive of the weight of wagons, at 15 miles per hour."

In pursuance of this call upon American genius three locomotives were produced, but only one of them was made to answer any useful purpose. This engine, *The York*, was built at York, Pa., and was brought to Baltimore over the turnpike on wagons. It was built by Davis & Gardner, and was designed by Phineas Davis, of that firm, whose trade and business was that of a watch and clock maker. After undergoing certain modifications it was found capable of performing what was required by the company. After thoroughly testing this engine, Mr. Davis built others which were the progenitors of the "grasshopper" engines which were used for so many years on the Baltimore & Ohio Railroad. It is a remarkable fact that some of these are still in use on that road, and have been in continuous service for over 50 years, which is probably the longest active life of any existing locomotives.*

Notwithstanding the fact that Phineas Davis was one of the earliest and most ingenious constructors of locomotives in this country, very little has been known of him until quite recently. Some months ago Mr. John C. Jordan, a resident of York, Pa., interested himself in the subject, and prepared an account of the life and achievements of Davis, which was published in the *Gazette*, a daily paper published in that place, from which Mr. Jordan has kindly permitted us to republish the following extracts:

"Phineas Davis was born in Grafton County, N. H., and was the son of Nathan and Mary Davis.

"He came to York when he was about 15 years old, poor, friendless and unknown. He presented himself barefooted, wearing a straw hat, and a bundle under his arm, to Mr. Jona-

* From an article in *Scribner's Magazine* of August, 1888.

than Jessup, a clock and watch maker, asking for employment. Mr. Jessup was struck with his intelligence, and employed him at once. He remained here until he was 21 years of age, and attained to great proficiency in his business. Mr. Davis had the reputation among those who knew him of being very reliable and ambitious. Toward the close of his service with Mr. Jessup as a watch maker he made a miniature gold watch of beautiful design about the size of a dime, which was an excellent timepiece, and attracted much attention as being a remarkable production. This watch afterward came into possession of his son, Willis Davis.

"Mr. Davis became a member of the Society of Friends July 5, 1815. He was married on November 15, 1826, in the Friends' meeting house in York, to Hannah Taylor. He had by this marriage two sons, Willis and Nathan. Willis was appointed an engineer in the U. S. Navy, and afterward entered the Confederate service. Nathan enlisted in the Union Army, and lost his life in Virginia.

"Mr. Davis, being an inventive genius, next turned his attention to the manufacture of steam engines, and formed a partnership with Mr. Israel Gardner, under the firm name of Davis & Gardner, in a foundry and machine shop.

"The first production of this firm of any importance was the iron steamboat *Codorus*, which was launched on the Susquehanna River about 1828."

Of this steamboat very little is known. In another article, published in the same paper from which we have quoted, Mr. Jordan quotes from a letter received from Colonel Granville Haller, a native of York, but now a resident of Seattle, Wash. He was born in 1819, and in his letter to Mr. Jordan says:

"The subject recalls to memory my witnessing the steamboat *Codorus* on wheels passing along Main Street, York, and when it reached the market square the width of the passageway was insufficient for the boat to get through, owing to an awning frame, whose supporting posts stood at the curbstones in front of the Demuth store, at that time in the Stair Building on the northwest corner of Main Street, when the awning was torn down without ceremony to enable the elephant to pass through at that corner. I was then a boy about 9 years of age.

"Small as I was, Mr. Davis in those days enjoyed an enviable reputation, among even the boys, as an ingenious mechanic as well as an inventor—also a Mr. Grimes (?)—I think that was his name. The former to us was a 'Big Injun heap'!—somebody above the ordinary run."

Another correspondent, General William B. Franklin, now a resident of Hartford, Conn., wrote to Mr. Jordan:

"I remember hearing about the steamboat *Codorus*, which, if my memory serves me, came to a sudden end by the bursting of her boiler."

Continuing his account of Mr. Davis's life in the York *Gazette*, Mr. Jordan says:

"In January, 1831, the Baltimore & Ohio Railroad Company issued an advertisement offering liberal inducements to the mechanical skill of the country for the production of coke or coal-burning locomotive steam engines. In response to this call upon American skill, three engines were offered in competition. The engine selected was called *The York*, constructed by Phineas Davis at the establishment of Davis & Gardner, on South Newbury Street. This engine was accepted as the best and put into active use on the railroad. As this was the first coal-burning locomotive steam engine ever built in the United States, York has the undoubted claim to that honor.

"The York *Gazette* of February 1, 1831, contains the following notice of the offer of the Baltimore & Ohio Railroad Company for steam engines:

LOCOMOTIVE STEAM ENGINES.

"'The Baltimore & Ohio Railroad Company being desirous to obtain a supply of American manufactured engines for their railroad, offer $4,000 for the most approved engine which shall be delivered for trial on their road on or before the first day of June next, and $3,500 dollars for the second best.

"'The engine must burn coke or coal, and consume its own smoke; it must be capable of drawing 15 tons at 15 miles an hour; it must not weigh more than 3½ tons; the pressure of the steam not to exceed 100 lbs. to the square inch; less pressure is preferred.

"'Davis & Gardner have been engaged in building an engine for some time past, and expect in the course of 10 or 15 days to have it conveyed to the city of Baltimore. We look forward to the trial with anxiety.'

"The York *Gazette* of February 15, 1831, has this notice of the day on which the locomotive will be taken to Baltimore:

"'The locomotive steam engine made by our citizens, Messrs. Davis & Gardner, is placed on runners, and will leave York for Baltimore this day.

"'Those of our citizens who have not visited it during its construction will not be less surprised to see it pass through the streets than they were some years since on beholding the iron steamboat *Codorus* making a similar passage. On its arrival at Baltimore, it no doubt will be received with applause and be followed by crowds to its place of destination.'

"Phineas Davis soon after became Manager of the Baltimore & Ohio Railroad shops. The first steel springs used in this country were placed upon *The York*, Davis's locomotive and tender, in September, 1832, under the superintendence of Mr. Davis.

"Mr. Davis was killed by an accident on the Baltimore & Ohio Railroad between Baltimore and Washington, on his return from Washington, where he had gone on the trial of an engine on September 27th, 1835.

"The York *Gazette* of October 10, 1835, published an obituary, copied from the Baltimore *Patriot*."

After relating the principal events of his early life, it is said:

"'Being endowed with inventive talents and industry of thought, and the bias of his mind leading to investigation into the principles of things, Mr. Davis next turned his attention to chemistry; soon, however, he applied himself to the science of steam, and as a consequence to the construction of steam engines, in which he took great delight. He pursued the business in that town for several years, making many experiments the while, tending to develop and illustrate the capabilities and power of that mighty agent, steam, and thus to serve a public end, though without materially advancing his private interests. He, in connection with his partner, built several steam engines, of various power and for various purposes, while prosecuting the business at York. In these the hand of improvement was constantly visible. Mr. Davis was literally a self-taught man, and, like all eminent men of that class, in whatever department of science or the arts, he was capable of achieving the most decisive results. Such men do not rest satisfied with existing improvements, but making the best use of their capabilities, and with all the past for a study, they go on with a steady and certain progress in carrying their several pursuits to a higher and yet higher degree of improvement and usefulness.

"'Such in an eminent degree has been the case with regard to Mr. Davis and his investigations connected with steam engines. The first efficient locomotive used upon the Baltimore & Ohio Railroad was constructed by Davis & Gardner, under his order and direction, at York, and brought here upon wagons; since then a large number of locomotives have been built for this great work, as also for the Washington Railroad, under Mr. Davis's immediate superintendence, and scarcely any one ever succeeded another without evincing some improvement in design or execution, and thus exhibiting the evidence of his profound reflection and high mechanical skill. The construction of locomotives was a business particularly suited to his taste and capacity. And the railroad company very soon discovered his value in that department, and offered such facilities as induced him to leave the concern at York in the care of his partner and engage in the work of making engines here in the immediate vicinity of the road. He had been so engaged for a couple of years, and by his talents, industry, and perseverance, under the liberal encouragement of the company, he had by successive improvements brought the locomotive to a high degree of efficiency. His mechanical aptitude and habits of study never flagged, but were true and available to the end. Their results were shown in some useful improvements exhibited in the last locomotive made under his direction, and finished for the Washington Railroad a few days ago.

"'It was after a successful trial of this engine on his return from Washington, whither he had given the numerous hands in his employ the gratification of a ride, that the accident occurred which brought his useful life to a sudden and melancholy termination. It arose from no fault of the engine or imprudence of its builder, but was the result of a casual and unseen defect in the railway. One of the chains had become broken, and the end of a rail being thus misplaced, caught the flange of the engine wheel and threw the engine off the track. The deceased was in the tender, where he had placed himself for the better observation of the working of the engine. A rapid progress at the moment of the accident brought the cars in the rear with great force upon the tender, and this in turn upon the engine. The perilous contact dashed the tender in pieces and in the same instant, it is hardly known how, so sudden was the catastrophe, deprived of life its solitary occupant. The assistant engineers who were on the locomotive, and the passengers, were uninjured. The remains of the deceased were brought into town on the afternoon of the accident and interred on the afternoon of the 28th in the Friends' burying-ground in Old Town, in the presence of a large group of sorrowing friends.

"'Mr. Davis was married some years since at York, and has left two orphan children of tender years in the care of a distant relative of their mother, now no more. The death of their last parent makes them orphans indeed. He leaves them, perhaps, a moderate portion of this world's goods, but the enduring legacy of a useful and blameless life and an example rich in the elements of instruction. For he was truly an estimable man in all the various relations binding him to society. And however highly he was valued as a mechanician, not less exalted was the estimate of his qualities as a man. However marked his usefulness and deep the regret at his loss, in a professional point of view, no less auspicious shone the amiable qualities of his mind and heart upon the circle of his friends, and no less profound will be their sorrow at this sudden removal of the individual. While they deplore his premature end, they will not cease to cherish his memory as that of one who possessed so many titles to the affectionate regards of his fellowmen. To close, in the language of an early friend who knew all his value, who long went step by step with him, in striking out new combinations in practical science and adding new trophies to human skill: Though his loss to the great field of mechanical improvement will be deeply felt, the community will suffer a greater loss in the impressive example of his excellent life.'

"Notwithstanding this statement of the remains of Mr. Davis having been interred in the Friends' burying-ground in Old Town, Baltimore, he was buried in York. I found in the records of the Friends' meeting-house, in York, an entry in the handwriting of Jonathan Jessup recording the interment of Phineas Davis in their burying-ground in York, Pa. His grave is unmarked and unknown."

THE GERMANS AS DRUMMERS.

Mr. J. C. Monagan, United States Consul at Chemnitz, reports to the Bureau of Statistics at Washington that "the present time is full of plans to open up foreign markets to German machines. This is due to their success at Chicago. To find out what is wanted in South American and African markets it is proposed to keep agents on the ground all the time, or send qualified agents at regular and frequent intervals of time. These agents must be men capable of studying the questions, not superficially, but practically and scientifically. It is only possible for men educated in technical branches to make such a study

"Engineers are to be sent to Brazil, La Plata, Mexico, Chile, Peru, and other South American States. The purpose is to 'drum up' trade. The costs are to be proportioned to the number of persons employed by the factories sending the engineers. It is hoped that enough will subscribe to keep the cost down to 50 or 75 cents per person employed. As an aid to the engineers, vast numbers of illustrated machine-explaining catalogues, printed in Spanish and the various languages of the people or colonists among whom they are to circulate, are to be sent before and after the engineers. Thus far, wherever and whenever the propositions to send engineers and catalogues have been discussed they have been voted for unanimously. The Foreign Office and the Prussian Minister of Commerce have expressed a lively interest in the movement, and have promised it aid. Nineteen firms, representing 7,506 workmen, have already subscribed. It is expected, so popular is the matter becoming, that many more will soon join. It is also proposed to have the engineers take orders for iron and steel products wherever they go whenever they can. This will help to keep down the costs to those taking part, and will permit of a much larger number of engineer agents being sent. The number, it seems, is to be limited only by the subscriptions. Everything about the plan commends it to the thoughtful consideration of our people as well as to the Germans."

Our consul adds, "Let us also, then, send out engineer agents—men trained in mechanics, and able to speak Spanish, French, or other languages. Let them carry catalogues and commissions to sell anything, from a paper of pins to a Corliss engine. Let our manufacturers, emulating the Germans, unite to pay the expenses. Let great efforts be concentrated in places offering a market."

We will remark that the American Engineer goes to all foreign countries in which there is any trade which might be obtained for this country. Therefore an advertisement in its pages is a monthly messenger dispatched to all parts of the world, and will cost much less than 50 or 75 cents for each person employed.

Manufactures.

A CONVENIENT DRAWING PEN.

The engraving below represents a very handy drawing pen, which is manufactured by the Bennett Manufacturing Company of 1510 Chestnut Street, Philadelphia. Every draftsman has experienced the inconvenience of changing the "nibs" of his pen to draw heavy or light lines at will. In the instrument which is illustrated, this can be done instantly without adjusting the screw which regulates the width of the lines. The screw *a*, by which the distance apart of the blades of the pen is regulated, instead of passing through the upper blade loosely and screwing into the lower one, as in ordinary drawing pens, is screwed into the upper blade and merely bears against the lower one. By turning this screw the blades are thus separated any desired distance. The minimum distance apart of the nibs of the pen is thus adjusted by this screw, but they can be sprung wider apart by means of a sort of trigger *c*, which is attached to the upper blade. The maximum distance which this may be moved is in turn adjusted by the screw *b*, which bears against the under side of *c*. By these means the narrowest or finest line that it is desired to draw is determined by the adjustment of the screw *a*, and the greatest width of line is regulated by the screw *b*. In using the pen the fine lines are drawn in the usual way. When a heavy line is required the nibs are separated as far as the screw *b* will permit by pressing with one finger on the trigger *c*. This arrangement has also another advantage—when the ink dries slightly at the nibs of the pen, they may be agitated by pressing several times on the trigger *c*, and the ink can thus be made to flow freely so long as it is liquid.

These pens, made by the Bennett Company, have aluminum handles, and are of excellent workmanship, and will be found a great "boon" by draftsmen who use them.

A CONVENIENT DRAWING PEN.

NOTES ON LONG GUNS.

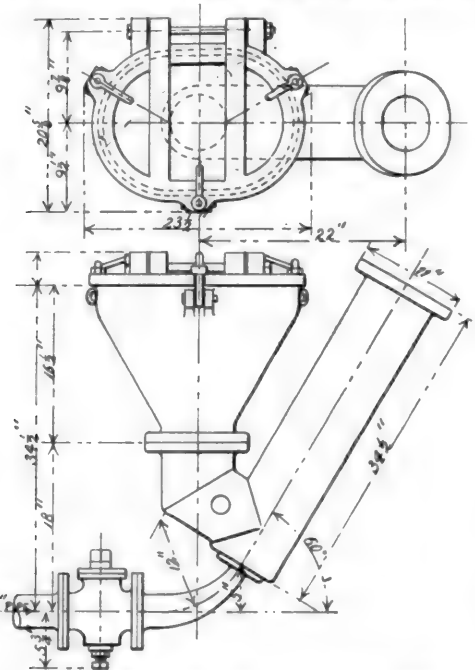
In *La Marine de France* is an interesting article on long guns generally, and the construction work of M. Canet more particularly. Without endorsing everything that is said in this article, we think that certain portions deserve great consideration. On the question of the guns' power of resistance, the writer observes that exaggerated fears have been expressed as to the effect of gas wave pressure. In the first place, the shocks to which the gun is subjected are not greater in a long than a short piece, if the pressure is kept within admissible limits—namely, 2,400 kg. or 15.2 tons per square inch. The same is true of the effect produced by erosion, which undoubtedly is the real cause of guns wearing out. Vibrations may be specially injurious to guns built up and composed of many elements, especially if not perfectly adjusted to each other by shrinking on. Displacements are no doubt often produced among hoops, which is one of the reasons why the new guns of great power made in France have but few elements and complete compactness, and their great length does not affect the question of resistance. Flexion or contortion of tube has given trouble in some navies, even with guns of medium length. The 110-ton guns of the *Benbow* and *Sanspareil* took a twist of double curvature, for which it was necessary to allow in aiming the gun at any object. The Krupp 11-in. gun, of 35 calibers, for Russian coast service, had, after firing, a permanent bend, varying from 3 mm. to 13 mm. These permanent deviations from the axis, when they attain a certain amount, interfere with the accuracy of fire, and may cause accidents, because the path of the projectile not being a straight line, wedging and bursting may be produced, and in all cases the sighting suffers from increased friction. This question has attracted much attention.

It is not necessary, however, that the gun should be exposed to the action of vibration for flexion to be set up. Guns, especially those made on old-fashioned principles, may bend by their own weight. This may be tested by measurement, and

found to alter on turning the gun round. In firing this is not found to affect the shooting. Hence this temporary flexion must be distinguished from permanent flexion. It is impossible to avoid this temporary flexion altogether, but it should be reduced to a minimum by the adoption of the best form or trace of piece. In the new guns for naval service Canet has a tube without hoops, which has great stiffness, and of which the moment of inertia with respect to the mounting is considerable.

The vibrations have no permanent effect on the chase or tube proper outside the question of dislocation of elements. The molecules retain their natural condition under continued or repeated efforts. Experience, however, teaches that it is generally in the first rounds fired, especially with heavy charges, that inconvenience is caused. A similar phenomenon is seen when a steel projectile, which has been badly tempered, breaks under the single blow of a hammer, or even spontaneously. Now although it is more difficult to temper long tubes evenly than short ones, this is not a sufficient reason to condemn the long ones.

A Canet gun of 57 mm., 80 calibers long, fired at Havre in May, 1892, and a piece of 19 cm. of 80 calibers long, on the same system, tested in September and December, 1892, also at Havre, did not exhibit any deviation in the tube. Projectiles of 2.7 kg. (5.95 lb.) and 13 kg. (28.66 lb.) attained velocities of 1,013 meters (3,323 ft.) and 1,026 meters (3,366 ft.). It has been objected that most of these guns have only fired a limited number of rounds, and that long-continued fire might produce injury; but there is nothing to justify this conclusion in experience up to the present time, but interesting trials, including testing to destruction, will probably soon be made at Gâvre. A gun may be made to bear continued strains as well as a bridge, and should a flaw cause it to yield rapidly, the evil is of a nature which may beset short guns as



DETAIL OF SEE'S HYDRO-PNEUMATIC ASH EJECTOR.

well as long ones. There is generally too much attention bestowed on resisting transverse strain, and nearly all guns have been constructed on theoretical principles which do not take account of the suddenness of the shock, nor of transverse or of flexional strains.

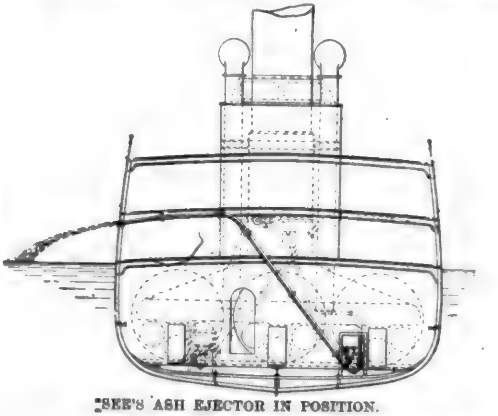
The new pieces have been constructed on absolutely different principles. A carefully designed form, after practical tests, offers all guarantees for a gun fired under reasonable conditions. The tendency is to increase the length greatly. The Director of Artillery, Colonel Roque, has taken a great step in this important question. He has ordered Canet guns of 55 calibers; and, at last, at Ruelle a 15 cm. (5.9 in.) gun of 90 calibers length has been tried with success. There is every reason to think that the guns of the future will be of great length.

With regard to service on board ship, great length has been thought to constitute a great difficulty. This has weight, no doubt, with regard to some vessels; but it is often possible to replace a 14 cm. gun by one of 10 cm. caliber of such a length as to be equally powerful, and to have a flatter trajectory. Much may be done also by alteration in the mountings and balance of the pieces. The question of length deserves special consideration, offering, as it does, a great increase in velocity and energy, which may be taken advantage of to obtain greater range, a greater zone of destruction, owing to the trajectory being flatter, and greater accuracy of fire.—*Engineer.*

SEE'S HYDRO-PNEUMATIC ASH EJECTOR.

We give herewith two engravings showing the application and construction of a hydro-pneumatic ash ejector, which has recently been designed and put upon the market by Mr. Horace See, of No. 1 Broadway, New York. All ocean travelers are familiar with the disagreeable features which sometimes are present when the ashes are thrown overboard on each watch, especially those who have had occasion to travel on steamers where there was no upper promenade deck. In addition to the disagreeable element which is so annoying to passengers, it, of course, involves an immense amount of work for the crew. The ash ejector which we illustrate does away with all of the manual labor outside of the actual shoveling of the ashes in the fire room, and they are thrown overboard so wet and mixed with such a quantity of water that passengers are not aware that anything of the kind is being done. The construction of the apparatus is exceedingly simple. The dimensions are all given on the drawing which we illustrate.

The apparatus consists of a hopper with a strong cast-iron



SEE'S ASH EJECTOR IN POSITION.

cover, which when not in use is kept closed. This hopper opens down into a large pipe inclined upward at an angle of about 60°. In the bottom of this pipe there enters the nozzle of the ejector, which throws water under a pressure of about 160 lbs. to the square inch, when the lift, from the fire-room floor to the discharge opening on the side of the steamer, is 20 ft. When the ash ejector is to be used a pressure of 160 lbs. is obtained in the 3-in. pipe back of the plug cock. This is then suddenly opened and the water allowed to pass through the pipe until it is filled and the discharge overboard begins. Then the cover is removed from the hopper and the ashes simply shoveled in. They fall down, are caught by the stream and carried overboard. In order that there may be no clogging it is found necessary to admit some air with the stream of water. This is done by placing an air-valve in the inclined pipe. Sometimes it is placed in the delivery pipe near the top of the hopper, and sometimes at the point marked by a circle in the engraving.

The apparatus has been placed on a number of vessels, and among others on the steamship *Lahn*, of the North German Lloyd Line. On this steamer about 135 tons of coal are burned a day, and the time required for getting rid of the ashes is 15 minutes for each watch. The apparatus, in addition to its simplicity, takes up with all of its connections much less space than any of the old methods. It will raise ashes no matter what the draft of the vessel may be, and as fast as the men can shovel them into the hopper.

AERONAUTICS.

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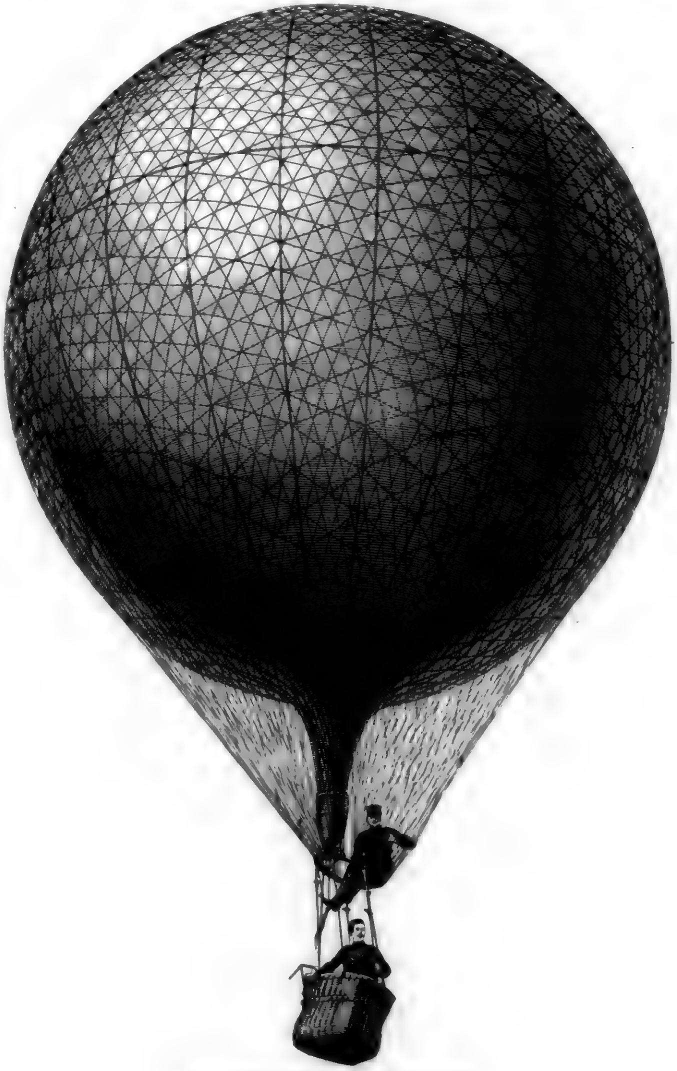

ENGLISH MILITARY BALLOON.

ANNOUNCEMENT.

An International Conference on Aerial Navigation formed one of the series of "congresses" which have recently met in Chicago. The meetings of this Conference proved to be successful and interesting beyond expectation. The efforts of the committee in charge of them to secure the co-operation of scientific and capable men, and reports of experimental investigations, facts and positive knowledge rather than speculations or descriptions of projects, was abundantly rewarded. Some 45 papers were contributed, covering many of the problems of aeronautics and aviation, and presenting the observations and results of experiments of experts who are eminent as scientific men or experienced engineers or both. The subject was taken out of the hands of "cranks" and was discussed by those who by reason of their knowledge and training were competent to do so. These papers are of very great interest to all who have any concern in the fascinating subject of aerostation.

At the conclusion of this conference the papers and proceedings were placed at the disposal of the editor of the American Engineer and Railroad Journal for publication in that paper, if it was thought judicious to make such use of them or any portion of them. After due consideration it was thought that as probably only a portion of the readers of that journal would be interested in the subject of aeronautics, that it would hardly be fair or wise to devote as much of its space to that subject as would be required to give all of the proceedings at the conference, or that portion of them which has special value. At the same time it was felt that the interest in aeronautics has grown, and is increasing so rapidly that it would be desirable to have all the proceedings at the Conference made accessible to those who are concerned in its subject. It was therefore concluded to print them in the form of a supplement to the American Engineer, which may be furnished to the subscribers of that paper at a small extra charge for subscription, and to whoever else might be sufficiently interested in the science and art of flight to be willing to subscribe to the supplement alone.

The proceedings of the International Conference on Aerial Navigation will therefore be issued in monthly parts, each having not less than eight pages the size of those of the American Engineer, which are the same as this, and printed in the same type (brevier), and of the size and form employed in the paper already referred to. The title of the new publication will be Aeronautics, Published by the American Engineer and Railroad Journal.

The following is a list of some of the most important papers which were presented at the Conference, and which will appear in the supplement:

"The Internal Work of Moving Air," S. P. Langley, Secretary Smithsonian Institute, Washington, D. C.

"Anemometry," S. P. Ferguson, Blue Hill Meteorological Observatory.

"Aviation," A. Goupil, Civil Engineer, Narbonne, France.

"Supporting Surfaces in Air," C. W. Hastings, Civil Engineer, deceased.

"The Air Propeller," H. C. Vogt, Naval Experimenter, Copenhagen, Denmark.

"The Screw Propeller," C. W. Hastings, Civil Engineer, deceased.

"The Elastic Fluid Turbine as a Motor," J. H. Dow, Mechanical Engineer, Cleveland, O.

"Motors for Flying Machines," C. W. Hastings, Civil Engineer, deceased.

"Materials of Aeronautic Engineering," R. H. Thurston, Director Sibley College, Ithaca, N. Y.

"Strength of Aeronautical Materials," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.

"Forms for Flying Machines," C. W. Hastings, Civil Engineer, deceased.

"Behavior of Air Currents," George E. Curtis, Smithsonian Institute, Washington, D. C.

"Meteorological Observations," H. A. Hazen, Weather Bureau, Washington, D. C.

"Observations of Birds," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.

"Gliding Flight," J. Bretonnière, Engineer and Observer, Constantine, Algeria.

"Soaring Flight," E. C. Huffaker, Observer, Bristol, Tenn.

"Sailing Flight," C. W. Hastings, Civil Engineer, deceased.

"Theory of Soaring Flight," Ch. de Louvrie, Engineer, Combebizou, France.

"Theories of Soaring and Sailing," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.

"Theory of Sailing Flight," A. M. Wellington, Editor *Engineering News*, New York City.

"The Advantage of Beating Wings," Ch. de Louvrie, Engineer, Combebizou, France.

"Equilibrium of Flying Machines," C. W. Hastings, Civil Engineer, deceased.

"The Equipoise of Flying Machines," A. F. Zahm, Professor Nôtre Dame University, Indiana.

"Experiments in Flying Machines, Motors, and Cellular Kites," Lawrence Hargrave, Experimenter, Sydney, New South Wales.

"Suggestions and Experiments," F. H. Wenham, Engineer, Goldsworth, England.

"Methods of Experimentation," A. P. Barnett, Experimenter, Kansas City, Mo.

"Learning How to Fly," C. E. Duryea, Mechanical Engineer, Peoria, Ill.

"A Programme for Experiments," L. P. Mouillard, Observer, Cairo, Egypt.

"Gliding or Soaring Devices," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.

"Various Experiments," E. C. Huffaker, Observer, Bristol, Tenn.

"Manufacturing Hydrogen Gas Balloons," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.

"Natural Gas Balloon Ascensions," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.

"Flotation *vs.* Aviation," Professor de Volson Wood, Stevens Institute, Hoboken, N. J.

"Navigable Balloon Flight," C. W. Hastings, Civil Engineer, deceased.

"Manœuvring of Balloons," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.

"Systematic Investigation of Upper Air," M. W. Harrington, Chief of Weather Bureau, Washington, D. C.

"Balloon Signals," Ch. Labroussé, Aeronaut, Paris, France.

"Observations from Balloons," C. C. Coe, Aeronaut, Ridge Mills, N. Y.

"Balloon Meteorology," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.

"Design of Navigable Balloon," General W. Hutchinson, British Army, Silverdale, England.

"Ten Miles up in the Air," De Fonvielle, Paris.

There was also much interesting discussion of these papers, a full report of which will be given.

In addition to the proceedings of the Conference on Aerial Navigation, there will be given each month the latest accessible notes, news, and information about aeronautical engineering with reports of experiments, investigations, and illustrations of new inventions, with original contributions and articles written expressly for its pages, editorial comments, selected matter from foreign and domestic sources. In short, it will be a small paper, and we believe the first one in this country devoted exclusively to this rapidly growing subject.

This first number will be followed by others which will appear monthly thereafter. The whole of the proceedings of the Aeronautical Conference will be given in 12 numbers, which will be issued from this date. Whether the publication will be continued after the expiration of that time will depend upon the success of the enterprise.

The American Engineer and Railroad Journal is edited and published by M. N. Forney, at 47 Cedar Street, New York. It is a monthly illustrated publication, each number of which has 48 pages of reading matter. It is devoted to mechanical engineering and railroad topics and interests. As the most important branches of engineering in this country are those relating to railroads, more space in its pages is devoted to locomotives, cars, signals, bridges, permanent way, etc., than to any other one class of subjects. Marine and stationary engineering, naval progress, ordnance, shop practice, tools, machinery, processes and methods of doing work, engineering notes, news, statistics, book reviews, etc., all receive due consideration.

The subscription price for the American Engineer is $3 per year for the United States and Canada, $3.50 per year for foreign countries.

For the American Engineer and Aeronautics, $3.50 per year for the United States and Canada, $4 per year for foreign countries.

For Aeronautics alone, $1 per year for the United States and Canada; $1.20 per year for foreign countries.

The proceedings of the Conference on Aerial Navigation will also be published in book form before they are completed in Aeronautics.

Subscriptions, orders, and other communications should be addressed, and remittances made payable to

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NEW YORK, OCTOBER, 1893.

CONTENTS.

PROCEEDINGS OF THE CONFERENCE ON AERIAL NAVIGATION.

HELD IN CHICAGO, AUGUST 1, 2, 3, and 4, 1893.

THE proposal to hold an International Conference on Aerial Navigation in Chicago during the Columbian Exposition first originated with Professor A. F. Zahm, of Nôtre Dame University. He conferred with Mr. C. C. Bonney, President of the World's Congress Auxiliary, an organization under the auspices of the World's Columbian Exposition, intended to promote the meeting of various congresses ; then he interested various persons in the project, and in December, 1893, a committee or organization was formed.

This committee, in consultation with President Bonney, decided to hold the Conference during the same week as the Engineering Congress, in order to secure the attendance of engineers at the discussions ; and the following circular was issued :

"Not things, but men."

President, Charles C. Bonney. Treasurer, Lyman J. Gage.
Vice-President, Thomas B. Bryan. Secretary, Benjamin Butterworth.

THE WORLD'S CONGRESS AUXILIARY OF THE WORLD'S COLUMBIAN EXPOSITION OF 1893.

Department of Engineering.

GENERAL DIVISION OF AERIAL NAVIGATION.

PRELIMINARY ADDRESS OF THE WORLD'S CONGRESS COMMITTEE ON AN INTERNATIONAL CONFERENCE ON AERIAL NAVIGATION.

IN connection with the various congresses which will be held next year, under the auspices of the World's Congress Auxiliary, it is proposed to hold in Chicago, in 1893, an International Conference on Aerial Navigation, somewhat similar to that which took place in Paris during the French Exposition of 1889 ; the subject being one which, while it has hitherto been left chiefly in the hands of the more imaginative inventors (perhaps in consequence of the prodigious mechanical difficulties which it involves), has of later years attracted the attention of some scientific men and engineers.

OBJECTS.—The principal objects of the Conference will be to bring about the discussion of some of the scientific problems involved ; to collate the results of the latest researches ; to procure an interchange of ideas, and to promote concert of action among the students of this inchoate subject.

It is proposed to invite the attendance of delegates from the various aeronautical societies of the world, and generally of persons who are interested in the scientific discussion of the subject.

TIME AND PLACE.—The Auxiliary Management has assigned the afternoons of three days for this conference, being Tuesday, Wednesday, and Thursday, August 1, 2, and 3, 1893. The opening session will take place at 2.30 P.M., on Tuesday, August 1, in one of the halls of the "World's Congress Art Palace," now being built on the Lake Front Park, at the foot of Adams Street, in Chicago. The sessions upon the two subsequent days will also take place in the afternoon, and may either, like the first, be joint sessions, or the members in attendance may divide into two sections (A and B) as may be decided hereafter.

TOPICS SELECTED.—The topics selected for papers and discussions are as follows :

I.—SCIENTIFIC PRINCIPLES—JOINT SESSION.

1. Resistance and supporting power of air, including results of recent experiments ; formulas for the resistance of balloons or flying machines, etc.
2. Best forms of aerial propellers, including results of experiments with screws, wings or other forms ; their efficiency and the power required.
3. Motors for aeronautical purposes, whether steam, gaseous, electric, explosive, etc. ; their effectiveness, safety and weight per H.P.
4. Materials for aeronautical construction, whether for balloons or flying machines ; including the strength and weight of fabrics, metals, woods, etc.
5. Best structural forms for aeronautical constructions, so as to combine strength and lightness ; to offer the least resistance to progression, and to alight safely.
6. Behavior of air currents, including observations at various altitudes ; the prevalence, the direction, the trend and the force of winds, etc.

II.—AVIATION—SECTION A.

1. Observations and experiments on the flight of birds, including their methods of rising, gliding, alighting, etc. ; measurements of power exerted and of velocities.
2. Theories regarding the soaring and sailing of birds. It is now generally admitted that birds utilize the wind in soaring, but no satisfactory explanation of the performance has been given.
3. Various types of proposed flying machines, their advantages and defects, the power required, their safety ; differences between natural and artificial wings, etc.
4. Equilibrium of flying machines, including the best means of securing safety with wings, screws, aeroplanes, etc., in rising, sailing, and alighting.
5. Novel experiments in aviation and their results, either with power machines, dirigible parachutes, gliding or soaring devices, models, etc.
6. Experiments with kites ; results of different forms as to stability, sustaining power, height attained, behavior, etc. A history of kites.

III.—BALLOONING—SECTION B.

1. Construction of balloons, choice of fabrics, laying out, cutting and sewing, varnishes, nets, cars, valves, anchors, guide ropes, parachutes, etc.
2. Inflation of balloons ; hydrogen, coal gas, natural gas, hot air, etc. ; their generation, cost, and management during inflation.
3. Navigable and war balloons, past experiments and results ; the present status ; the resistance, propellers, motors, speeds, etc.
4. Manœuvring of balloons, ascending and descending, with least expenditure of ballast or gas ; utilizing wind currents, determining altitudes, etc.
5. Observations in balloons, meteorological, photographic, topographical, military, naval, planimetric, etc. ; various instruments required.
6. Proposed improvements in balloons, as to forms of minimum resistance, increased strength and stiffness ; with calculations of power required and lifted.

The Organizing Committee may arrange upon application for the introduction and discussion of topics not enumerated in the above list.

PROCEEDINGS.—It is intended to introduce each of these topics by the reading of one or more papers thereon, to serve as a basis for discussion, and to draw out further information. These introductory papers will be obtained both by solicitation of the Organizing Committee and by voluntary contribution. They need not be long nor very exhaustive, but decided preference will be given to those stating the results of actual experiments; as facts and positive knowledge are deemed more instructive than theories or projects. It is expected that some of these papers will be printed and distributed in advance, in which case it will be preferred to receive discussions thereon in writing.

No paper will be read unless it has previously been approved by the Committee of Organization. The management of the World's Congress Auxiliary will appoint the officers to preside over the various sessions, and these officers will arrange the order of the proceedings, call up in their turn the various papers, and the speakers whom the Organizing Committee may have selected to discuss them. Papers previously printed will generally be presented by abstract, so that discussion may follow without loss of time. Persons desiring to join in the discussions will be expected to give previous notice, and the remarks of speakers will generally be confined to fifteen minutes, and to not more than two speeches upon the same subject. It is preferred that speakers shall subsequently furnish a *résumé* of their remarks in writing, failing which the stenographer's notes will be edited by the committee.

Stenographers will be in attendance, and interpreters will be provided when previous notice has been given of remarks to be made in other than the English language.

It is expected that a separate room will be provided, in which to exhibit, on approval of the committee, small models or interesting experiments during the intermissions between the meetings. Should circumstances warrant, one or two additional sessions may be held.

CARDS OF ADMISSION.—Personal cards of admission to the Conference will be issued in advance by the Secretary of the Organizing Committee upon application to him, appproval by the Committee, and the payment of a contribution of $3 to the publication fund. These cards will entitle the holder to attend the Conference and to receive all of its subsequent publications.

PUBLICATIONS.—The Committee of Organization will decide how much of the papers and proceedings shall be printed, and will cause the same to be edited. Such of the papers as may be printed in advance will be mailed to the holders of cards of admission who may request it, and designate the particular topic or topics which they desire to discuss. Written discussions thereon should be forwarded to the Secretary in advance of the Conference, and after its close all such papers and discussions as may be printed shall be mailed to the members thereof.

ORGANIZATION.—The President of the World's Congress Auxiliary has appointed a local committee to organize the affairs of the proposed Conference. It is to be assisted by an Advisory Council consisting of the leading scientific authorities on the subject throughout the world. Persons desiring to secure cards of admission or to contribute to the papers or discussions are requested to advise the secretary at an early day, stating in the latter case what is the class of researches or experiments which they have made, and on what topics they desire to receive advance papers.

All communications should be addressed to Professor A. F. Zahm, Secretary, Nôtre Dame, Ind.

O. CHANUTE, *Chairman*.
A. F. ZAHM, *Secretary*.

ELISHA GRAY, LL.D.,	E. L. CORTHELL,
H. S. CARHART,	R. W. HUNT,
S. W. STRATTON,	D. J. WHITTEMORE,
IRA O. BAKER,	J. W. CLOUD,
JOHN GUERIN,	B. J. ARNOLD,
B. E. SUNNY,	W. N. RUMELY.

Committee of the World's Congress Auxiliary on Aerial Navigation.

WORLD'S CONGRESS HEADQUARTERS,
CHICAGO, ILL., December, 1892.

A large number of letters were written to those persons in various parts of the world who were known to be experts or students of the several topics selected, and the effort was made to secure at least two papers by competent writers upon each of the topics, so as to present two points of view for discussion.

Favorable responses were at first somewhat slow in coming, so that only a few papers could be manifolded in typewriting, and none were printed; but toward the last of July, 1893, papers came in abundance, and were of a high order of merit.

Cordial letters of co-operation were also received from the British Aeronautical Society, the Aerial Navigation Society of France, the Aviation Society of Munich, the Imperial Aeronautical Society of Russia, and the Aviation Society of Vienna.

A meeting of the Organizing Committee was held, to decide upon what papers should be submitted to the Conference. A few were rejected altogether, as being imperfect, or presenting untried projects, and some papers it was decided to present but not to print afterward, as not possessing sufficient interest for permanent preservation.

The programme as printed comprised forty-seven papers, but this included contributions from several persons who had treated more than one of the topics selected; notably the paper of Mr. G. Crossland Taylor, and the treatise on the problem of aerial navigation of Mr. C. W. Hastings, the various parts or chapters of which were presented in the programme under the appropriate topic. It has been thought best not to follow this division in publishing the proceedings, but to print the papers as originally received.

It was, of course, impracticable to read all these papers in full. Some were presented *in extenso*, and some were given in abstract, in order that discussion might follow.

The Conference took place in the Memorial Art Palace, in Chicago, August 1, 2, 3, and 4, 1893, the session upon the first day (Scientific Principles) being presided over by Mr. O. Chanute, Chairman of the Organizing Committee; the second session (Aviation) being presided over by Dr. Thurston, Director of Sibley College, Cornell University; the third session (Ballooning) was presided over by Colonel W. R. King, of the U. S. Army; while the fourth session was a supplemental one, in which the various topics presented were further discussed.

The attendance at each session comprised about one hundred persons, who seemed to take great interest in the proceedings, and the discussions brought out several investigators who had been studying the subject or trying interesting experiments without making it publicly known.

OPENING ADDRESS.

By O. CHANUTE

It is well to recognize from the beginning that we have met here for a conference upon an unusual subject; one in which commercial success is not yet to be discerned, and in which the general public, not knowing of the progress really accomplished, has little interest and still less confidence.

The fascinating because unsolved problem of aerial navigation has hitherto been associated with failure. Its students have generally been considered as eccentric—to speak plainly, as "cranks;" and yet a measurable success is now probably in sight with balloons—a success measurable so far that we can already say that it will probably not be a commercial one; while as to flying machines proper, which promise high speeds, we can say that the elements of an eventual success, the commercial uses of which are not as yet very clear, have gradually accumulated during the past half century.

The truth of these assertions, which will be justified further on, seems to indicate that it is not unreasonable for us as engineers, as mechanicians and as investigators, to meet together here in order to discuss some of the scientific principles involved, and to interchange our knowledge and ideas.

The present is, I believe, the third international conference upon aerial navigation. The second took place in Paris in 1889, and a fourth is projected to take place in that city during the Exposition of 1900.

The conference of 1889 undoubtedly forwarded the possible solution of the problem by making the public aware that a number of sane men were studying it in various parts of the world, by making these men acquainted with each other's labors, and by disseminating information concerning the scientific principles involved, the mechanical difficulties to be surmounted, and the practical details of aerial construction generally. Probably as a consequence of this very considerable advance has been made during the last four years, as will be indicated hereafter, and a number of promising proposals are now in progress of experiment and development.

We may fairly expect similar results to follow from the present conference. We may hope to collate here considerable knowledge concerning the scientific principles involved, to gain information concerning the latest researches, and to establish some concert of action.

Indeed, we shall begin our proceedings with the presentation of a paper by Professor Langley conveying what may almost be said to be the exposition of a new natural law, hitherto but dimly suspected, which seems to hold out promises of important consequence.

We neither expect nor desire the presentation here of new

projects for navigable balloons or for flying machines. We have endeavored to secure instead the statement of general principles and of the results of actual experiments, as facts and positive knowledge are deemed more instructive than projects or speculations.

Success, when it comes, is likely to be reached through a process of gradual evolution and improvement; and the most that we can hope to accomplish at present is to gain such knowledge of the general elements of the problem as to enable us to judge of the probable value of future proposals, both as mechanical or as commercial enterprises.

More important still, we may perhaps help to enlighten a number of worthy but ill-equipped inventors who are retrying old experiments, with no proper understanding of the enormous mechanical difficulties involved.

As a preliminary to our proceedings, it will probably be interesting to you to have a brief survey of what has already been accomplished, both with balloons and with flying machines, and of the advance which has been achieved since 1889.

As regards navigable balloons, the latest reliable information is probably contained in an interesting and carefully prepared paper, read by Mr. Soreau, C.E., before the French Society of Civil Engineers in February last, and discussed at the April meeting of that society.

You know that it has been abundantly proved that elongated balloons of large size can be made sufficiently stiff by internal gas pressure to stand driving at low velocities. The best speed hitherto obtained in any public trials has been 14 miles per hour, which is quite insufficient to stem the wind upon any but rare occasions. This speed was achieved by Commandant Renard, of the French Military Aeronautical Department, in 1885. The balloon was 165 ft. long and 27½ ft. in diameter, carrying an electric motor weighing 1,174 lbs., which developed 9 H.P. The motor, therefore, weighed 130 lbs. per horse power.

Now, the French technical papers announce, and Mr. Soreau confirms, that during the past winter Commandant Renard has been constructing a new war balloon 230 ft. long and 42¼ ft. in diameter, which is provided with a new motor said to be of 45 H P., and to weigh with 10 hours' supplies, between 2,640 and 3,080 lbs., or at the rate of about 66 lbs. per horse power. With this apparatus, and with a screw some 30 ft. in diameter, it is said that Commandant Renard expects to obtain a speed of 24¼ miles per hour, and that this will enable him, for about three-quarters of the days in the year, to stem the winds that blow.

Granting that the statements made about the motor are true (and there is nothing improbable about them, as we shall presently see), and also that the motor (the details of which are kept secret) shall not break down upon trial, I see no good reason to doubt the attainment of the speed estimated; and we may learn any day that it has been performed, although it is understood that the French authorities are maintaining such secrecy as they can concerning this new war engine.

But the Germans also, as well as several other European nations, are said to be in possession of navigable war balloons; and should war break out in Europe (which Heaven avert!) we might be very soon made aware of the fact that speeds of 25 miles an hour are practicable.

I have no doubt about it myself; but the attainment of this moderate speed requires very large, and, therefore, very costly balloons, which carry very few passengers; and it is clear that while such craft may be justified by the exigencies of war, they cannot compete commercially with existing modes of transportation.

The difficulty with navigable balloons is that they must be of very great dimensions for even moderate speeds and very light, useful loads. As the cubic contents of the gas bag increase at a higher ratio than the surface of its envelope, the relative lifting power increases with the size, and therefore more powerful motors can be taken up and more speed obtained; but we soon reach the limits of practicability. The new French war balloon is 230 ft. long (as large as a lake steamer), and it will carry but three or four passengers at 25 miles an hour, so that it is difficult to conceive how, if they be made of sufficient size to carry even a score of passengers, such enormous and frail craft can be handled, housed, or operated without peril of casualty or disaster.

The conditions as to resistances, lifting power, propellers, and motors are now pretty well known; the speeds can be calculated with approximate accuracy; and while improvement can doubtless be achieved in the energy of the motor, in the efficiency of the screw, and especially in the form of the navigable balloon to diminish the resistance, it may be affirmed with confidence that railway express train speeds cannot be attained with balloons of practicable dimensions. They may be used for war purposes or for exploration, but while we may say that the balloon problem is approximately solved, we may also say that the solution does not promise to become a commercial success, or to yield a large money reward to inventors.

With artificial flying machines proper, should a practical one eventually be developed, very much higher speeds may be expected. The pigeon flies at 60 miles an hour, the duck at 90, the swallow at 125, and the marten is said to flash through the air at something like 200 miles an hour. Professor Langley has lately shown that, within certain limits, high speeds through the air will be more economical of power than low speeds, and recent advance in light steam-engines seems to have reduced them to a less weight per horse power than is generally thought to obtain with the motor arrangement of birds. It seems, therefore, not unreasonable to entertain the hope that man may eventually achieve a mechanical success (if not a commercial one) in the attempt to compass a mode of transportation which so strongly appeals to the imagination, and that it may result in greater speeds than pertain to our present journeyings.

The mechanical difficulties in obtaining safe support from so intangible a fluid as air are, however, so great that men would long ago have given up the attempt if it had not been for the birds. But, then, there are the birds; and some of them at least—the sailing birds, concerning which you will hear something in some of the papers to be read here—seem to be able to soar indefinitely upon the wind with no muscular effort whatever, so that the argument which has been made that man cannot hope to float his greater weight than theirs upon the air would seem not to be well founded.

But, as already stated, the mechanical difficulties are very great, and it is not surprising that they should have deterred many men competent to advance the solution of the problem from considering it at all, and that it should have mainly been left in the hands of the more imaginative and ill-informed inventors, who, with imperfect knowledge of the elements of the problem, believe that success is to be achieved through a single happy thought.

It is a mistake to suppose that the problem of aviation is a single problem. In point of fact, it involves many problems, each to be separately solved, and these solutions then to be combined. These problems pertain to the motor, to the propelling instrument, to the form, extent, texture, and construction of the sustaining surfaces, to the maintenance of the equipoise, to the methods of getting under way, of steering the apparatus in the air, and of alighting safely. They each constitute one problem, involving one or more solutions, to be subsequently combined; and these are the elements of success already alluded to as having gradually accumulated, which I propose to pass in review, more particularly to appreciate what has been accomplished since 1889.

First, as to air resistances and the support to be obtained from its inertia, we have had the magnificent labors of Professor Langley, published in 1891, showing, by careful experiments that something like 200 lbs. can be sustained in the air by the exertion of 1 H.P. One half of this weight has already been supported per horse power in some experimental machines.

Then, as to the motor: Mr. Maxim has recently announced that he has constructed two steam-engines of 300 H.P. which, with the engine proper, the boilers, pumps, generators, condensers, and the weight of water in the complete circulation, weigh but 8 lbs. to the horse power. With respect to the propelling instrument, Mr. Maxim has, since 1889, made a great many experiments with aerial screws. He finds, like Commandant Renard before him, that some forms are very much more effective than others, so that the coefficient of efficiency, which was less than 35 per cent. in the earlier aerial screws, may now be said to be at least double this amount.

On the other hand, Mr. Hargrave, who now has built and experimented some 18 different flying machines, all of which fly, says that he has obtained equal propulsive effects from screws and from beating wings, although he rather prefers the latter. A paper from him, giving the results of his latest experiments and describing his steam-engine and boiler, which weigh only 10.7 lbs. per horse power, will be submitted to this meeting.

As to the best form, extent, texture, and construction of sustaining surfaces, there is yet considerable uncertainty; but there will be submitted here two papers upon materials of aeronautical construction—one by Professor Thurston and the other by Mr. G. Crossland Taylor—both of which are well calculated to advance knowledge on this subject; while the experiments of Mr. Phillips in England a few months ago have shown that with peculiarly shaped blades of wood about 72 lbs. per horse power can be supported in the air.

The equipoise is, in my own judgment, one of the most important problems yet to be solved in aviation. No success is

to be hoped for unless the apparatus is stable and safe in the air—safe in starting, in sailing, and in alighting. Three-quarters at least of past failures can directly be traced to lack of equilibrium. This problem seems to be in process of solution; and I may mention in this connection that during the summers of 1891 and 1892 M. Lilienthal, of Berlin, has been gliding downward through the air "almost every Sunday, and sometimes on week days," upon an aeroplane with which he expects eventually to imitate the soaring of the birds, when he has learned to manage it safely.

Several of the papers to be read here propose various methods for first acquiring this necessary skill, for first learning to fly under safe conditions before venturing to launch forth in the air. This bird-science seems to be the first requisite, for safety is indispensable; and it may not be secured in free air until skill has been acquired in handling a machine.

The problems of starting up into the air, of steering, and of alighting safely upon the ground cannot yet be said to be in process of solution. Various methods have been proposed for getting under way, the principal of which have been to gain speed upon the ground or to get a lifting action from rotating screws; but neither has as yet been practically demonstrated as quite practical upon a working scale.

For the purpose of steering it has generally been proposed to employ two rudders, one vertical and one horizontal; but it yet remains to be known whether they will prove quite effective under the varying circumstances of flight.

The alighting upon the ground is likely to prove the most difficult and dangerous of the problems to be solved. It has been much too little considered by would-be inventors and patentees of flying machines, and it may long prove a bar to the success of such apparatus, for nothing but direct experiment, and that of a perilous kind, will determine how this operation can be successfully performed.

I hope, however, that you will agree with me that some of the elements of success have gradually been accumulating, and that there has been real, substantial advance within the last few years. There is still much to be done; but a number of experimenters have each been working on one or more of the several problems involved, and they have made it more easy for others to forward the general solution still further.

From this brief review of recent progress it would appear less unreasonable than it seemed a few years ago to hope for eventual success in navigating the air, and it may now be reasonably prudent to experiment upon a small scale, particularly if the inventor does so at his own expense; for the chances of commercial success seem still too distant to invite others to engage in the actual building of a flying machine unless they do it with the understanding that they may perhaps lose their money. This is the course which has thus far been followed by the three or four experimenters who now seem in the lead, and it may not be long before they achieve such success as fairly to warrant them in proceeding to the construction of a full-sized machine.

In any event, without concerning ourselves overmuch with the possible commercial uses of such apparatus, we may hope here to advance knowledge upon this interesting problem, and to be of service to those ingenious men who are seeking for its mechanical solution.

ON THE PROBLEM OF AERIAL NAVIGATION.

By the Late C. W. Hastings.

The late C. W. Hastings was a young civil engineer who was much interested in the problem of aerial navigation. He was for a time an assistant to Mr. O. Chanute, from whom, as he expressed it, "he learned much that he knew on the subject." He studied all the publications which were accessible, and made some investigations of his own, more particularly upon the aerial propeller, which will be found to be quite fully discussed in the following pages.

Finding that his health was failing, he devoted the last few months of his life to preparing the present essay.

He knew that he was dying from an incurable disease of the heart, and he bore his sufferings with a serenity and cheerful patience which touched his friends to the quick, devoting his remaining feeble strength to revising his work for publication.

He died, at the age of 33 years, in October, 1892, bequeathing this essay, which was not quite revised to his liking, to his friend, Mr. W. H. Breithaupt, who has edited it and contributed it to the Conference on Aerial Navigation in Chicago, where it was presented in abstract under the heads of the various topics selected. It is here published as originally arranged by Mr. Hastings, who thus contributes, even after his death, to the advancement of knowledge.—Ed.

INTRODUCTORY.

To those who have given the subject of aerial navigation but little attention, it will appear that gravity is the insurmountable difficulty which prevents its achievement; gravity is so evident an obstacle, and so evidently a great one, that very many people will readily believe that with gravity overcome, aerial navigation should be quickly accomplished.

That gravity has been overcome is too well known, and yet aerial navigation, except in an experimental and unsatisfactory way, has not been accomplished. The overcoming of the great obstacle, combined with the almost complete failure to reach the desired end, has resulted in creating the very reasonable and almost universal belief, that the problem of aerial navigation is impossible of solution. Scientific men, however, make an exception in this almost universal skepticism, and nearly all of them are willing to admit that when sufficient progress shall have been made in mechanical science, true aerial navigation will be possible and will be accomplished.

Transit through the air, when accomplished, must be an improvement in some particular upon the present methods of transportation, or it will be worthless. The aerial craft either must carry heavy cargoes for less money than present systems cost, or it must carry cargoes at higher speeds than present systems are capable of attaining, or transit must be effected to points which it is impossible to reach by other systems, or transit in such aerial vessels must possess features of enjoyment which other methods of travel do not have.

Aerial navigation, as at present known, has none of these preferences, save possibly the last, and its expense is so great as to prohibit indulgence in it. The successful aerial craft must be commercially successful in some of the ways mentioned; for a craft which would only navigate the air in time of war, for military or naval purposes, would hardly be considered to have solved the problem in a much more satisfactory way than it has already been solved.

If the problem of aerial navigation is to be discussed by engineers, it must be discussed as other engineering problems are. There must be generally accepted physical laws, or empirical formulæ, and there must be reliable experimental data, and the whole must be treated mathematically. An attempt will be made to do this in the following pages, but owing to the fact that the subject has received so little attention from scientists, the experiments that can be depended upon are few, and the empirical formulæ will certainly need modification in the future. There are therefore many places in these pages where an apparent conclusion is reached, but this apparent conclusion is only perfunctory and may be greatly changed. At the same time there are places where the conclusion reached is final, for it is based upon absolute physical laws, and not upon empirical formulæ, or meager experimental data. The reader will have no difficulty in determining one kind of conclusions from the other.

If the author repeats, and without credit, statements made by others, he does it unintentionally. Credit has been given wherever it has been thought to be due.

No attempt has been made to indicate any particular form of apparatus for aerial navigation; nor have any suggestions been made regarding experiments which it may be necessary or desirable to try. This policy is not pursued with the desire to conceal anything, but should this indication be attempted, it would at once be assumed that the writer had tried to solve the problem of aerial navigation, and criticism would be based upon that assumption. The paper claims only to be an attempt to indicate the road over which the successful inventor of aerial navigation must travel. Should this be clearly understood by engineers; if they are made aware of just what knowledge is required in order to accomplish aerial navigation, it is the belief of the writer that that knowledge will eventually be forthcoming.

BALLOON FLIGHT.

Gravity being the greatest apparent obstacle to flight, it is but natural to suppose that with this great obstacle removed, aerial navigation should soon be accomplished. It is now over a hundred years since the invention of the balloon* overcame the attraction of gravitation in so great a measure that man was enabled to rise vertically to an indefinite distance. Nevertheless aerial navigation has not yet become a commercial success, save as some curiosities are commercial successes.

* Stephen Montgolfier made the first successful balloon ascent in June, 1783.

Since the balloon certainly overcomes gravity, and can be designed to raise any weight, most of the money which has been spent up to the present time upon aerial navigation has been spent upon balloons, and upon attempts to make them navigable, and since such machines have not as yet come into general use, it is plain that they are so far commercially impracticable.

The navigable balloon consists of a cylindrical gas bag with pointed ends; it is driven through the air in the direction of the longer axis, which is horizontal. The shape is adopted so that the resistance of the air may be as small as possible, and motion is obtained from the thrust of the screw, which is turned by any suitable motive power. Steam, electricity and manual power have been used as motors.

Four such balloons have been manufactured, the most successful one being that made under the auspices of the War Department of the French Government. This balloon has made seven recorded trips, achieved a speed of 14 miles per hour, and on five of the seven occasions was able to return to the starting-point. None of the three other so-called navigable balloons deserves the name, for none of them has ever been able to return to its starting-point, and none of them was ever tried but once.

These facts are rather discouraging to those who hope to achieve aerial navigation through the means of a navigable balloon. If the French Government by the use of more money than the most enthusiastic company of promoters could hope to secure, and with, presumably, the best ability that it was possible to obtain, aided also by the fact that Frenchmen possess almost exclusively all experience in navigable balloons, and that they practise general ballooning to a far greater extent than other people; if the French Government with these advantages, and with several years of diligent trial, was unable to achieve more than the very moderate success stated, it would seem as if it were useless for others to attempt to solve the problem in this way, and without government aid. But there are much better reasons than this why the navigable balloon cannot be made commercially successful.

It has been shown that by merely doubling the size of the French War balloon, its speed could be increased from 14 miles per hour to 25 miles per hour. The reason is easy to see. The force which a body has to overcome in passing through a fluid is due to the resistance of that fluid, and if the body retains the same relative shape, but only increases in size, then the resistance for the same speed will increase as the area of the greatest cross-section. If the balloon be doubled in all of its dimensions it will hold eight times the amount of gas that it did at first, and will possess eight times the lifting power; but the area of its greatest cross-section will only be increased fourfold. If the motor weighs a stated amount per horse power, then it is seen that the balloon will carry eight times the power that it did at first, but that it will meet only four times the resistance. Its proportionate power is therefore twice as great as that of the smaller balloon, it is in fact twice as powerful, and had the dimensions been multiplied by three, it would have been three times as powerful.

The double-sized balloon, however, would not travel through the air at twice the speed of the smaller-sized apparatus, for the speed of a vessel moving through a perfect fluid will only vary as the cube root of the power consumed, so that the double-sized balloon would only travel

$$\sqrt[3]{2} = 1.259,$$

say, 25 per cent. faster than the smaller vessel, if the increase in all the parts, size of operators, etc., were precisely the same. As a matter of fact, however, there are so many things in the double-sized balloon, which would be of precisely the same weight as in the smaller apparatus, that the power could be increased much more than eight times, with the result that a speed of 25 miles per hour could be obtained instead of 14×1.259, 17.5 miles per hour as theory would indicate.

Had the dimensions been multiplied by three instead of by two, the possible increase in speed, as shown by theory, would have been

$$\sqrt[3]{3} = 1.44 = 44 \text{ per cent.}$$

Theory therefore leads us to expect that the increase in speed will be equal to the cube root of the increase in the dimensions. This principle has been known for some time, and has not only been known, but has been the foundation for some elaborate calculations and extensive patents which were taken out in 1885 by the late Mr. E. Falconnet, member of the American Society of Civil Engineers.

The balloon built by the French Government was 165 ft. long and 27½ ft. in diameter; the cargo inclusive of the aeronauts weighed 780 lbs., and the speed was 14 miles per hour. The navigable balloon of double the size would carry 1,500 lbs., and the speed would be 25 miles per hour. The voyages in both cases would be limited to a few hours. The smallest apparatus proposed by Mr. Falconnet was about the size of the latter, and the "practical" machine, which he believed would be most used, was to be about a quarter of a mile long and 200 ft. in diameter.

A general consideration, which the most casual investigator would make, must show him that the small cargoes and low speeds, of which the smaller machines are only capable, would make them commercial failures. The large forms of apparatus which were proposed by Mr. Falconnet could hardly have been kept under cover, and a wind such as occurs in almost any part of the world, at some time in the year, would inevitably demolish such a frail structure of such vast expanse as a balloon a quarter of a mile long and 200 ft. in diameter.

There is one element in aerial navigation by the use of balloons that has not been touched upon by writers on the subject, and that is the cost of maintenance. This omission can be accounted for by the fact that there has been no maintenance. Of the four navigable balloons constructed three have been tried but once, and then abandoned; the fourth was under the control of the French Government, and was the subject of many experiments and changes, while it is probable that reliable data of this nature could not be obtained, even if it has been thought desirable to keep the record.

It is evident that if the navigable balloon is to be kept in "commission" as many hours in the day and as many days in the year as is the steamboat or locomotive, the cost of maintenance will be ruinous. The income from a navigable balloon must therefore be very considerable in order to meet its maintenance. The character of the material of which it is constructed is so fragile, that the apparatus is extremely liable to accident, and, as compared with wood or iron, it is very shortlived; those capitalists, therefore, who may venture their money in a navigable balloon project, should calculate on large rates of profit to compensate them for the risks of the business, and in any case should expect to get their money back in a very few months or not at all.

Those who desire to still further investigate navigable balloons will find the subject succinctly and quite completely treated in a lecture by O. Chanute, C.E., before the students of Sibley College, Cornell University, published by the *Railroad and Engineering Journal*, New York.

DYNAMIC FLIGHT.

Since balloon or static flight can probably never be a commercial success, there remains only the other kind to be considered—that is to say, dynamic flight. This is at present practised by living creatures which weigh at most only 50 lbs., and imitated by some toys of about as many ounces. No flying creature exists that approximates the weight of any flying machine which would be termed successful.

As the above facts are favorite and very relevant arguments which are brought by those who believe that aerial navigation for man will never be more than a dream, it may be paramount to inquire why the flying creatures are all so small. Nature has probably developed as large a walking animal as the laws of mathematics and of the strength of material will permit, and it also seems reasonable to believe that the whale is as large an organism as the laws which govern physical structures will allow.

Since the mammoth and the mastodon were certainly smaller than the vehicles which man has constructed to navigate the land, and since the whale is not the largest body which can navigate the water, it seems reasonable to think that the eagle, albatross, or condor are not the largest bodies which can navigate the air by dynamic flight.

To any who have paid the least attention to flight, it must be evident that there are two kinds of dynamic flight—namely, beating flight and sailing flight. In the former kind the animal seems to be in many cases sustained by the wings pressing directly downward upon the air, and producing an upward reaction equal to the weight by means of a direct downward thrust. In this way the smallest of flying animals, insects, and humming-birds may keep their bodies motionless in calm air, and even fly backward as well as forward, though they do the former but slowly. As we investigate the flight of the larger animals we find that none of them ever fly backward, and that the pigeon is about as large a bird as can raise itself vertically through calm air; it only does this with an evident effort and for short distances.

Larger birds than the pigeon are only able to rise vertically when under some extraordinary excitement, and the largest of all are unable to rise vertically at all. This shows that the action of the wing in large birds is not vertical, and as we

watch them we see that their efforts are made to obtain not vertical, but horizontal motion. When the large bird rises from the ground he will do so by facing the wind and running against it; if he launches himself from a perch, it is never horizontally or upward, but always downward. If the hunter gets to the windward of a flock of wild turkeys, he can capture them, for the birds are unable to rise with the wind, but if he is to the leeward of them, they will spread their wings and easily escape. If the condor can be induced by bait to enter a small enclosure which is a little larger than his body and with its sides a little higher than his head, the bird will be unable to escape, for he cannot rise vertically.

As a very general statement, then, it may be said that large flying animals fly by sailing, and that small flying animals fly by beating their wings. To be sure there are many exceptions to this rule, for there are myriads of forms in nature; the butterfly will sail in an unsteady manner for a short distance, and the wild goose is an exceedingly strong flapping flyer, but the statement is quite true in a general way, and is truer in a definite way than most people suppose. The reason must, of course, be that it is easier for the small animal to fly by beating than it is by sailing, and that it is easier for the large flying animal to fly by sailing than by beating. They will both fly in the manner which consumes the least power.

Theoretically the weight of any motor will vary as the cube of its dimensions, while the power which it can exert will vary as the square of those dimensions. If we have two steam-engines precisely similar differing only in size, and running at the same piston speed and boiler pressure, the area of the piston, and therefore the power developed, will vary as the square of the dimensions, while the weight will vary as the cube of those dimensions. Now this statement seems absurd to the practical engine builder, for he knows that as a matter of fact the weight of an engine per horse power will decrease as the size is increased. The truth is, that no two engines have been made exactly alike except in size, and that also when the size is greatly decreased the internal friction becomes such a proportion of the load that the operation of this law is scarcely perceived.

In nature, however, the case is different. Here the internal friction is negligable, and the difference between the largest and the smallest of motors is so very great that the operation of the law can be observed. The contractile power of a muscle per square inch of section is about the same whether it be taken from a large or from a small animal. It is about 20 lbs. per square in. The rapidity of contraction is perhaps no greater in the muscle of the rapid-flying bird than in the rapid land animal. At any rate, the difference is not remarkable. It is seen, therefore, that the energy of the muscle will increase with the square of the dimensions, while the weight of that muscle will increase with the cube of those dimensions. It is for this reason that the ant can lift another ant with ease, that the man lifts his fellow-man only with difficulty, and the elephant is unable to lift its fellow at all.

Now while the small animal can exert greater energy in proportion to its weight than the large animal, and is therefore better adapted to beating flight, which, as has been observed, requires more power than sailing flight, it is not so well adapted for sailing flight. Sailing flight requires a considerable horizontal velocity, and this means a considerable opposing force due to the resistance of the air.

In order that the body shall meet with as little resistance as possible, the sectional area of the greatest cross section should be as small as possible. This sectional area will increase with the square of the dimensions, while the weight or mass will increase with the cube of the dimensions. Sailing flight undoubtedly requires mass, momentum, and this mass or momentum decreases much faster than the sectional area when the dimensions decrease. There will be a point in the decrease in size where the mass will be so small in comparison with the resistance created by the sectional area of the greatest cross-section, that sailing flight will be impossible; just as a speck of dust is the sport of every zephyr, while the huge stone, although of the same specific gravity, will withstand a hurricane.

Since the resistance increases much slower than does the momentum, as the size increases, we may expect that the larger flying animals will be of more rapid flight than the smaller, and as a general rule, with the numerous exceptions due to the numerous forms which nature has developed, this also is true.

Referring to the decrease in the proportional strength of the muscle with its increase in size, it is seen that there must be a point in increase of size, where the flying animal would be unable to raise itself vertically from the ground, just as there is a point in the increase of size where the quadruped would be unable to travel by walking. There does not, however, seem to be any such mathematical reason to limit the size of the animal which could travel by swimming; and since, for the same speed, the resistance met by a body in moving through the air will increase as the square of the dimensions, and since the power of the living motor will also increase as the square of the dimensions, it would seem as if there would be no limit indicated by mathematics to the increase in size of the creature which would fly by sailing. This, however, is quite misleading, for the power required for support must be considered in discussing aerial navigation, while in marine navigation no such power is required.

The theory of the power increasing as the square of the dimensions of the motor has only been applied to the living machine. It applies there, as already stated, because the motors are similar, and because the internal friction is small; the operation of the law can also be observed because the motors vary so greatly in size. In discussing balloon flight we assumed that the power of the motor would vary as the weight, and this can be assumed to be about true in the construction of artificial motors, where no two are made precisely similar, where the internal friction of small sizes is great, and where we find no such great variation in the sizes experimented with as to attract our attention to this law.

Orthogonal Flight.

Two kinds of dynamic flight have been mentioned—*i.e.*, beating flight and sailing flight. We may now alter these terms a little to "orthogonal flight" and "gliding flight." Orthogonal is a term devised and employed by the French, and indicates that kind of flight in which the weight is sustained by a direct downward dynamic thrust upon the air. Thus the insect or humming-bird, when holding its body motionless in the air, is practising orthogonal flight; if a screw were arranged upon a vertical shaft, so that by rotating it raised a weight through the air, that would be orthogonal flight; any arrangement of valvular wings, which are intended to open when the wing is raised and to close when the wing is depressed, and so lift an apparatus up through the air, would be designed for orthogonal flight. In an apparatus intended to operate by orthogonal flight, the action of the moving machinery is expected to produce an upward reaction of sufficient force to raise the machine, and horizontal translation is not an essential condition, as it is in gliding flight.

Perhaps an estimate of the amount of power required to raise a man vertically through the air by this means will not be uninteresting. This power must be applied so as to drive the man upward and the air downward, and this being the case, the least power will presumably be used when the greatest possible quantity of air is operated upon.

This latter statement may be illustrated by the case of a cannon and its ball. Suppose a cannon weighing 1,000 lbs. and a cannon-ball weighing 1 lb. to be free in space; the charge is exploded, and the same force—namely, the pressure exerted by the powder—acts on both the cannon and upon its ball for the same length of time while the ball is travelling from the breech to the muzzle. Now although the force and the time during which it is exerted are the same in the case of the cannon and of the ball, the power which is imparted to each, and which is conserved in their momentums, differs. By Newton's second law of motion, the velocities of the cannon and of the ball under these circumstances will be to each other inversely as their masses; the ball will therefore be traveling 1,000 times as fast as the cannon. Now since the power contained in the momentum of any mass is proportional to the square of the velocity and to the mass itself, we see that the power conserved in the cannon will be represented by $1{,}000 \times 1^2 = 1{,}000$, and that the power conserved in the momentum of the cannon-ball will be $1 \times 1{,}000^2 = 1{,}000{,}000$. The latter amount of power is 1,000 times the former. When two bodies are acted upon by the same force for the same length of time, the power conserved in the momentum of each will vary inversely as their masses.

In orthogonal flight, therefore, the greater the amount of air acted upon and driven downward, the less will be the power required. The amount of air acted upon will increase directly as the surface and as the speed employed.

All this may be shown by a numerical example. Suppose an apparatus to weigh 300 lbs., and to be supported by an arrangement, often proposed by inventors, of valved wings, which will permit the air to pass through when the wing is raised, but which will close when the wing is depressed, creating resistance and so raising the machine. Let there be two separate surfaces, one of which is being raised while the other is being depressed. In this way one will be in action at all times. Suppose that the area of each of these surfaces be 300 sq. ft., and that the resistance when they are raised through the air is nothing.

The resistance upon a plane surface in passing through the air is, as ascertained by Professor S. P. Langley, and here expressed in terms of feet and seconds instead of in the metric units he gives:

$P = 0.00152\ V^2\ S.$

P = pressure in pounds.

V = velocity in feet per second.

S = area in square feet.

By the assumption made $P = 300$ lbs. and $S = 300$ sq. ft. (for only 300 of the 600 sq. ft. are acting); substituting in the equation, we have

$$300 = 0.00152\ V^2\ 300;$$

from this we find that $V = 25.6$ ft. per second, and since a horse power is equal to 550 foot-pounds per second, the power required will be

$$\frac{300 \times 25.6}{550} = 14 \text{ H.P.}$$

This is plainly more than a man could develop. If the man weighed 150 lbs. there would be remaining (300 − 150) 150 lbs., which would be the possible weight of the material out of which to construct 600 sq. ft. of surface.

Suppose that we make the entirely unreasonable assumption that two such wings, each with 1,200 sq. ft. of surface, could be constructed out of 150 lbs. weight, we should then have the following:

$$300 = 0.00152\ V^2\ 1{,}200 \qquad V = 12.8 \text{ ft. per second,}$$

and

$$\frac{300 \times 12.8}{550} = 7 \text{ H.P.}$$

We thus see that with four times the surface only one-half the horse power is required to accomplish the same work—that is to say, the power required will vary inversely as the square root of the surface, or

$$\frac{1}{14} : \frac{1}{7} :: \sqrt{300} : \sqrt{1{,}200}.$$

This may be shown mathematically, for neglecting constant coefficients the formulæ just used become

$$P = S\ V^2 \text{ and horse power} = P\ V.$$

If we double the surface and retain P constant, we have

$$P = 2\ S\ \frac{V^2}{2} = 2\ S\left(\frac{V}{1.414}\right)^2.$$

The new surface then becomes $2\ S$, and the new velocity

$$\frac{V}{1.414},$$

so that the new horse power is

$$P\left(\frac{V}{1.414}\right).$$

That is, the surface has been doubled and the power required has been decreased by the square root of two.

We thus see that the power required will vary inversely as the square root of the surface.

We may undertake to ascertain by these equations how large a surface would be required for a man to raise 300 lbs. vertically by his muscles with the particular arrangement supposed. Suppose that a man can develop continuously one-eighth of a horse power, we can make the proportion:

$$\frac{1}{14} : \frac{1}{0.125} :: \sqrt{300} : \sqrt{x}\quad x = 3{,}760{,}000 \text{ sq. ft.} = 86.5 \text{ acres};$$

but in order to enable the man to fly we must have another surface similar to this, because one will be inactive all the time, making 173.0 acres of surface to be constructed out of 150 lbs.

While it is evident that man cannot by his own muscular efforts expect to overcome gravity in this way, an artificial motor may perhaps do so. If we can construct 600 sq. ft. of surface of the weight of 150 lbs., and a motor developing 14 H. P. and weighing only 150 lbs., two requirements which it is probably not impossible to meet, it is seen that the apparatus would rise, but it would have to go without an attendant.

We infer from this that the use of valvular wings, which has been so often proposed, is not advantageous, and that orthogonal flight is scarcely practicable.

The use of the screw in this connection will be discussed later.

Gliding Flight.

It being seen by calculation and by general observation that orthogonal flight requires much more power per pound weight for its accomplishment than gliding flight, and since the lack of power is one of the greatest obstacles in the way of successful aerial navigation for man, it is almost certain that of the two kinds of flight the latter will be the one adopted. It is more economical in the matter of obtaining support and also of obtaining horizontal translation, without which flight is worthless.

The force which gives support in gliding flight is easily realized. Take a fan, let the flat side be almost horizontal, and move it horizontally through the air; if the forward edge be raised a trifle higher than the rear edge, a strong uplift will be felt. Now there will be some resistance to horizontal motion, but if the inclination of the fan be very small, this resistance will also be small. It will be very much less than the upward thrust. This is the principle by virtue of which birds obtain support in gliding through the air. The large bird glides upon apparently horizontal wings, but which are, in fact, slightly inclined, and the force which sustains him is the same as that which tends to raise the fan. At the angles at which it is estimated that birds usually sail, the horizontal resistance will be from one-sixth to one-thirtieth that of the upward pressure—that is to say, the force required to move the bird's wing horizontally through the air, and so sustain his weight, is only one-sixth to one-thirtieth of the weight itself. It must be remembered in this connection, however, that force is not power. The above statement simply means that 1 lb. of pressure applied horizontally to a thin inclined plane, moving through the air at the angle and the speed usually adopted by sailing birds, will keep that plane in motion horizontally, and will sustain from 6 to 30 lbs. weight.

This pressure upon the air by the supporting surface is, by the well-known laws of fluid pressure, always normal to the surface. The direction of this pressure is at right angles to the surface at all times, and this being the case, the resistance to horizontal motion and the uplift can be determined by simple trigonometrical resolution of forces, if the normal pressure be first ascertained.

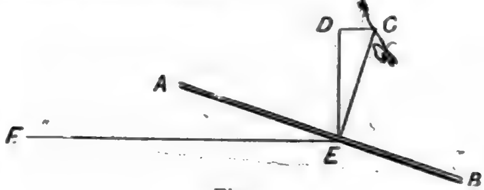

Fig. 1.

If $A\ B$, fig. 1, be the surface upon which the horizontal current $F\ E$ is impinging, the direction of the force created by the pressure of that current will be along the line $E\ C$, which is always at right angles to the plane; and if the length of the line $E\ C$ represents the amount of this normal pressure, the length of the line $E\ D$ will represent the uplift, and the length of the line $D\ C$ will represent the resistance to horizontal motion. It is seen that the line $E\ D$ is equal to $E\ C$ multiplied by the *cosine* of the angle $D\ E\ C$, and that the line $D\ C$ is equal to the line $E\ C$ multiplied by the *sine* of the same angle. This angle, $D\ E\ C$, is equal to the angle $F\ E\ A$, which is the angle of inclination of the plane. The uplift, therefore, is equal to the normal pressure multiplied by the *cosine* of the angle of inclination, and the resistance to horizontal motion is equal to the normal pressure multiplied by the *sine* of the angle of inclination. It is also seen that the resistance to horizontal motion is equal to the uplift multiplied by the tangent of the angle of inclination, or that the uplift is equal to the resistance divided by that tangent. We have therefore:

$$W = N \cos. @ \quad R = N \sin. @ \quad R = W \tan. @ \quad W = \frac{R}{\tan. @},$$

in which W is the weight or the uplift, R is the resistance to horizontal motion, N is the normal pressure upon the plane, and @ is the angle of inclination.

Now since power is resistance multiplied by velocity,

$$H\ P = V\ R = V\ W \tan. @,$$

in which V is the velocity and $H\ P$ the power.

If $H P$ is in English horse power, it will be 33,000 foot pounds per minute, 559 foot-pounds per second, or 375 mile-pounds per hour; if we make W the weight in pounds and V the velocity in miles per hour, we shall have:

$$H P = \frac{V W tan. @}{375},$$

or

$$H P = 0.002667 \ V W tan. \ @,$$

in which $H P$ is the English horse power, V is the velocity in miles per hour, and W is the weight or uplift in pounds. The author believes this last formula to be original, and it is seen that it is applicable to any fluid.

It will be noted that the extent of the surface is not an element in the formula. If, therefore, we can ascertain the velocity, the weight, and the angle employed by sailing birds, we can ascertain the power consumed by them in mere support. Two of these elements are comparatively easy to estimate, the weight and the velocity; but the angle of inclination is still an unknown factor, and the difficulties of measuring that angle are so great, that it is doubtful if any reliable data will be obtained in regard to this matter for some time to come.

There is another element which enters into gliding flight, which has not been considered, and this is the supporting surface. It is important, both in view of its size and its shape. If it is small, a high velocity or a considerable angle will be required to sustain the weight, and this, as we see by the formula just given, means great power; if it is too large, its own weight will be considerable, which, we also see by the formula, will require more power, and even if the area were determined most accurately, its shape would be a matter of serious consideration. As will be seen further on, the power consumed will vary not only when the shape of the surface is varied from plane to curved, but also, in the case of surfaces with unsymmetrical outlines, as different edges of the surface are placed at the front or at the side.

(*Written for* AERONAUTICS.)

THE SECRET OF SOARING.

By FRANK H. WINSTON.

THE power that certain birds have of mounting to great heights and floating over vast areas on apparently motionless pinions has been a subject of interest for many centuries. Seemingly authentic accounts of partially successful attempts of man to soar have come down to us from as far back as the first century A.D. But the unfortunate and sometimes comical results of these trials and the universal failure to apply the principles of ascent prove conclusively that this art was not much better understood then than it is now.

Some writers have argued that because a magician known as the Saracen " rose on the wind as a bird" some time during the twelfth century, and Dante was seen floating over Lake Thrasimene and sailed over the public square of Perugia, they must have known the secret of this mode of flight. The results, however, do not seem to warrant this deduction. The Saracen's success was only momentary. The jump from the tower of the Hippodrome against a strong wind carried him upward until the momentum had been overcome by the wind. Not understanding the necessary adjustment of the supporting surfaces at this juncture, or the conditions indispensable to further flight, " his body," to quote from the naïvely written account of the episode, " having more power to draw him downward than his artificial wings to sustain him, he fell and broke his bones."

The description of Dante's rising above Lake Thrasimene is so meager that a conjectural analysis only can be attempted. Being a mathematician, doubtless he was able to compute the amount of surface needed to support his weight in a moderate wind or by a vertical fall, having previously ascertained, by experiment, the action of aeroplanes under certain conditions and when used at different angles to the horizontal. Had his estimates been correct, he could have risen a short distance from a boat or raft. A spring against the wind, with the angle of incidence not too great, would have floated him upward until the force of the spring had been exhausted; and if the wings had been large enough he would have continued to rise while floating backward until the retrograde movement had lessened the lifting pressure below supporting efficacy. Then, had the pitch of the wings been reversed, he could have descended toward the point of starting.

A similar feat was performed by De Sanderval about the year 1880 near Mont Redon, when an ingenious safety device, noticed further on, was used by him.

It is more probable that Dante started from some high point of land on the lake and pursued a similar course to that followed when he sailed from the highest tower in the city of Perugia across the public square, and " balanced himself for some time in the air." His flight was then a gradual descent, like that of a bird when soaring in still air. Unfortunately for him in the latter case, a forging in one of his wings gave way, and he fell on a church and broke his leg. No mention is made of his rising to any height; and the natural inference would be that he must have been much lower when he fell than at the start, otherwise his injuries must have been greater. Nothing in the account indicates a knowledge of the real methods employed in soaring beyond the lifting power of an aeroplane falling from an elevation and possibly the action of moving air on an inclined plane, both of which have been pretty fully understood for some time.

Indeed, the essence of soaring, the power to float upward without visible effort, has, so far as known, remained a mystery. M. de Sanderval, in an article published in *La Nature*, describing some experiments tried by him between 1873 and 1881, declares that " birds can rise in space without flapping their wings by describing, at high speed and with wings extended, a wide helix of very short pitch," but fails to show how the high speed is gained. After relating his method of suspending his aeroplane from a cable stretched between two hills, he adds the following bit of intricate information: " I found it possible, after some swinging, to obtain a circular motion, in which I felt a sensation of a notable lightening of my weight. It would then have required the least stress to lift me in air, my purchase being upon a number of molecules (on the horizontal instead of the vertical line, as in the vertical fall) so much the greater in a given time in proportion as the horizontal velocity was greater."

No longer ago than 1885 the ENGINEER, in a lengthy editorial on " Aerial Navigation," referred to a theory advanced by a Mr. Lancaster, of Florida, who claimed that soaring is the result of some peculiar form of soaring birds, which divides the wind in such a manner that the pressure is greater on the back parts than on the front, so that the bird is forced forward against the wind. It also seems that Mr. Lancaster claimed to have forced small boards against the wind by giving them the required shape. After explaining the theory and illustrating it by diagram, the ENGINEER thus concludes: " Is it possible to construct a body so the required result will be obtained? So far as can be seen, *birds are so constructed*, and we may add that Mr. Lascaster's own experiments tend to show that the problem can be solved. It is not at all improbable that the world is on the brink of a cognate discovery concerning aerial navigation." This article was considered worthy of being copied in the *Scientific American* supplement, and appeared in the May number of that year.

Only last year Professor Langley, one of the most earnest and eminently successful students in aerodynamics, in his charming article on " Mechanical Flight," tacitly admits that there is a mystery connected with soaring which he has not been able to unravel, and refers to the works of Darwin and Mouillard for confirmation of his statements concerning the powers this type of birds possesses.

Yet the elements of this mode of flight are as simple and comprehensible as the movements of other animals. That a sight so common to the mountains and the sea has so long remained a partial mystery can only be explained by the fact that the exhibitions of the essential principles unobscured by confusing variations are seldom seen, and the distance and ever-changing positions presented to view make accurate examination exceeding difficult.

During the summer of last year it was my good fortune to become acquainted with a couple of hawks of the soaring variety, which had taken up their abode on a large and rugged bluff overlooking Cuchillo Creek, where the bottom land spreads out in the little valley known as the Stone Ranch. The hawks had been unmolested for some time, and were accustomed to see people working in the fields, and I was able to observe them under many circumstances. I have stood on the crags above the valley and have seen them float below me, then rise on their spiral course until they seemed but specks in the deep blue of a New Mexico sky. I have sat under the cotton woods and have seen them sail over me not fifteen feet away. I have watched them sweep down among the weeds, then mount upward again without a flexion of the wings, and have seen them slowly near the ground and be compelled to resort to ordinary flight until they had acquired sufficient velocity to again soar or until the wind freshened.

From the knowledge gained in these observations I would class soaring—soaring in this article being used exclusively as meaning flight without the flapping of wings—into four divisions. First, the horizontal or forward and upward move-

ment, the result of a previously acquired momentum, while the wings, or both wings and body, are elevated at the front. It is common to nearly all birds, and is of limited duration. Second, the forward and descending movement, the result of the dropping of the bird on inert air with the wings and sometimes the body depressed at the front. The vertical course taken is cycloidal, loss in elevation being but little after the first few yards. This method is also common to most birds.

It may not be out of place, before describing the other methods employed in soaring, to correct an impression which seems to have taken hold of many in regard to the relative location of the center of gravity in birds to the support of the wings. It is common to speak of the center of gravity as being located back of the support given by the wings. While this is true in ordinary flight, for the wings pull as well as lift when in motion, it is not the case when soaring, for the wings are locked in the desired positions by powerful muscles, and have the same effect as though the body, wings and tail formed one continuous rigid plane of varying surface. Lift a dead bird by its wings, and the body hangs downward; but spread it on a table, and a line passing through the center of the supporting surfaces will be found to pass through the body back of its junction with the wings, and nearly or quite through the center of gravity. The tail is used more for balancing and steering than for support. The combined surfaces of the wings being much greater than those of the body and tail, the poise of the body is controlled by the position of the wings. If the body is inclined upward the wings will be found to be a trifle more so; a change of the body to an opposite inclination is preceded by a similar change in the wings, but the body may remain in a horizontal position while the wings are slightly inclined either way.

The third method is an irregular forward and upward movement against a breeze of unequal intensity, in which the movements of the bird resemble those of a boat floating on billows. It is a combination of the first two phases in connection with an intermittent wind. The bird usually meets the first gust with a previously acquired motion and slightly elevated front, and before the force of the wind has overcome the momentum and inertia of the bird it has floated to a considerable elevation above its former level, measured by the velocity of the wind added to that of the bird and modified by the weight, the relative supporting surfaces, and the angle of incidence. The wind moderating, a forward movement is obtained by dropping a part of the acquired elevation, as in the second method, and a second gust is met in the same manner as the first. These successive manœuvres are continued until the desired elevation has been reached or until the wind slackens. It will readily be seen that if an increased elevation is not the object, by dropping, after each gust has subsided, the whole distance gained during the wind internal, an average windward motion would be the result. This style of soaring is seldom attempted without being combined with other movements, and cannot successfully be done in a steady wind. Its effectiveness depends upon the size of the bird being suited to the duration of the gusts of wind and periods of abatement. A frequent combination is performed by rising during the continuance of the wind, and before the bird's momentum is entirely overcome it describes a semicircular course and descends in a leeward direction; and again circling, meets the second gust and mounts upward while facing the wind; then again turning, descends as before. This is a combination of the third movement and the one about to be described—a combination that enables the bird to cover a long distance with the wind or to circle in a nearly horizontal plane during an intermittent breeze.

The spiral and last division is that in which motion is gained by floating with the wind while presenting considerable resistance, and this motion being then directed by a circular course against the wind with a diminished resistance, while the wings, and at times the body, are at an angle of incidence to the direction of the wind, whether floating with it or driving against it. This supports the bird in a nearly horizontal circular track or elevates it during the windward course, as may be determined by the bird. In the latter case it is drifted with the wind about the same distance as it gains in altitude. Motion is derived and maintained in very much the same manner as in Robinson's anemometer, the difference being mainly in the power the bird possesses of producing a greater variation in the degrees of resistance to the wind, and the necessity of its weight being supported by an aeroplane action during flight. When the circles of motion lie in the same general direction, the course taken during an upward flight is similar to an inclined spiral spring.

It was while witnessing a masterly ascent by the spiral method of considerable duration that I was enabled to analyze the use of forces employed in soaring; and as that method gives a clearer idea of this mode of flight than the ever-changing combinations usually resorted to by birds generally, a more detailed description may not be out of place. The bird, having a certain momentum caused by gradual descent or by ordinary flight, faces the coming breeze, and the wings are elevated at the front so much that the whole undersurface takes a strong upward slant as soon as the force of the wind is encountered. The smooth surface of the feathers while they are pressed closely to the body by the wind, the pointed body, and the rounded edges of the wings when spread present the least possible resistance. The bird is floated upward by its own momentum and the force of the wind acting on its slanted undersurface, but before its momentum has been overcome its wings are set at angles differing from each other, so that the inner wing presents more edge resistance and less sustaining power than the outer. This change, assisted by an adjustment of the tail, causes the bird to take a circular course and to cross the wind at right angles with a constantly decreasing velocity. The outer wing having more lifting power than the inner, the undersurface is tilted upward, forming a lateral inclined plane to the wind while crossing its path. Occasionally in this part of the course the angle of incidence becomes too great, and the bird is obliged to allow the outer wing to swing over the back to prevent its being overturned. The clumsier the bird the oftener this happens.

If the flight thus far has been properly made, the circular course is slowly continued. Indeed, after crossing the wind the momentum seems to be quite exhausted; but the bird assumes a lateral horizontal position by an equal extension of the wings. Their back edges are raised, and the wind, striking from behind, spreads the feathers covering the body, largely increasing its bulk, and ruffles the undersurface of the wings and opens a multitude of cavities in the feathery mass, while the pressure against the inclined plane formed by the wings tends to lift the bird as long as its velocity is less than that of the wind. The greater bulk and ruffled plumage, acting like sails set to catch the breeze, rapidly augments the velocity. The support gradually decreases as motion increases, and the bird begins to drop as its velocity approaches the speed of the wind; but before that is reached the outer wing is made to present more wind resistance than the other, and the greater push on that side continues the circular course, and the bird crosses the wind with almost an equal velocity to the wind, and at a higher level than when it first met the breeze. Another adjustment of the wings and the bird faces the wind with a force gathered from itself to again mount upward, as before.

Whether elevation or simply support in a horizontal plane is desired, the actual course taken is formed of cycloidal curves, the length of the cycloidal space lying with the direction of the wind. In the former case the segment of the course where the flight is with the wind is much longer than that in which it opposes the wind, a part of the force gained on the leeward course being consumed in lifting the bird on the windward. Horizontal flight is a combination of the spiral with the third method, or is a modification of the fourth, where the angle of incidence offered to the wind is only enough to gain in elevation what is lost while drifting. The leeward and windward distances are nearly equal, so that the bird in a moderate breeze moves at will on a nearly horizontal plane, and when the directions of flight are changed first to the right and then the left whenever the wind's path is to be crossed, or this method of soaring is combined with or superseded by others, according to the fancy of the individual bird, the movements become not only the embodiment of grace and beauty, but are exceedingly confusing to the interested observer.

When the general direction the bird wishes to take is with the wind, it rises by the spiral method, then gradually descends by the second method, as here classed, and acquires a greater velocity than the wind measured by its flight in still air, which is usually 10 to 20 miles an hour, added to the speed of the wind. When it nears the ground it again ascends as before. They seldom attempt to soar against a strong wind if it is continuous.

I have seen buzzards, vultures, and several varieties of hawks soar, and I once saw a large raven clumsily using the spiral method with success, and none of these birds differed in the methods used; the only difference noticed was in the perfection of their movements. The vultures when rising from the ground could not lift their wings when fully extended, the ends drooping like wilted leaves on the upward stroke, and it was with difficulty that they got under way.

When the breeze sprang up they spread their great wings to their full extent and rose in graceful curves as if by some unseen power, their fronts presenting thin and nearly straight lines, with a slight swell at their centers.

Careful observations seem to warrant the following state-

ments. No bird can soar in a direct line, horizontally or in an upward direction, further than the same momentum will carry a like aeroplane. No bird can rise by soaring to any great height without using the wind. Ascent can be accomplished in a wind from 8 to 10 miles an hour, the best results being with a velocity of 15 to 25 miles. Elevation having been gained, the descent, after the first few yards, in comparatively still air or with the wind, is small, while the nearly horizontal distance is great, the bird dropping just enough to keep its forward velocity equal to what is needed for support and over coming edge resistance. The wings are the aeroplanes which, with some assistance from the undersurfaces of the body and tail, support the bird in air and control all movements in soaring by their relative positions to the body and to each other. They produce similar results whether fully extended or projected in the shape of an obtuse letter V. The latter is the one used when rest is required, there being less strain on the muscles and less care needed in balancing, but with the disadvantage of loosing more in altitude than when the wings are fully spread.

When a bird wishes to remain near a certain place, unless the wind be blowing at the time, it descends in circles. The drop is then easily seen as each circle is a little below the preceding; but when it approaches one in a direct course it appears to rise as it comes nearer, although actually descending. After it has passed overhead and is receding it appears to drop faster than is really the case.

The secret of soaring being known, the question naturally arises, Can this knowledge be put to any practical use for the benefit of man? It is doubtful if the answer can be other than a negative, for no matter how interesting it may be to watch the ingenuity and skill displayed by these birds in grasping and controlling the forces of the wind for their own benefit, the fact still remains that soaring is, in comparison to ordinary flight, as the sailing vessel is to the modern steamship. Their flight is slow and tortuous, and is dependent upon an uncertain element. The only redeeming feature is the small amount of energy expended—an important factor in extended flights in high altitudes and in those of sea birds.

Man not possessing the muscular power for orthogonal flight which is sometimes needed to recover balance, a large element of danger will of necessity enter into his attempts in this direction. There is no valid reason, however, why man cannot imitate this type of birds, and, if he is willing to brave the dangers incident thereto, become skilled in riding upon the air. To do this he must not only be willing to undergo long and careful practice, but must be quick of action, with every nerve and muscle under perfect control, cool and collected in the face of danger, and be possessed of the power of balancing in a high degree, for any false movement might be fraught with fatal results. Doubtless this feat, if accomplished, will be classed in the same category as rope walking, trapeze performing, and like exhibitions of skill rather than with the useful arts.

A strong frame of steel tubes covered with canvas on the sides and bottom and having a support on which a man could lie with arms and legs free, sails of sufficient size to support the machine when occupied in a moderate breeze pivoted to the frame, an arrangement for turning the sails on the pivots placed in a convenient position for the hands, and a rudder or tail to be moved by the feet, would be the essential skeleton for such a machine. Pouches open at the rear and made to fold upon each other like the scales of a fish by pressure from the front, and to open out to catch the wind from behind, attached to the canvas covering of the frame, and portions of the undersurface of the wings and arrangement of slats like those of a Venetian blind, to be opened at will by the operator, forming a part of the wing surface, would be the necessary additions. The pouches, while offering but little impediment to forward motion, would expand and act as sails when going with the wind, and the slats, when closed, would form a part of the wing surface, and when open reduce that surface and at the same time produce a greater edge resistance, two conditions which seem to be conjunctive in soaring, and would obviate the necessity of constructing the wings, so they could be contracted and expanded.

That sails or wings of the needed size and strength and not too heavy for the purpose can be made has been proved by M. de Villeneuve, who built a steam bat which lifted him, in addition to the machinery, from the ground, the steam being supplied through a rubber hose from a stationary boiler.

The practical operation of the machine could be learned while it was attached by a rope to a cable stretched across a gorge, a safety device used by M. de Sanderval in his experiments on flight, already mentioned. By using an aeroplane composed of a couple of wings having a spread of some 40 ft and suspended from a cable, he was able to oscillate at pleasure in a wind of 18 or 20 miles an hour without any support from the connecting rope. Equilibrium was maintained by his weight being suspended below the wings, and a change of inclination was effected by ropes attached to the lower surface of the plane. Not understanding the conditions necessary for soaring by the spiral method, his attempts in that direction were complete failures.

Suspended in this manner, a vertical fall from any position not directly under the point of attachment would be converted into an oscillatory movement by the connecting rope, and all danger of serious injury avoided. This safety appliance could be improved upon by the supporting rope being run through pulleys hung on the cable and wound up on a drum as fast as there was any slack by an attendant, and let out as needed during the manœuvres of the machine, control being maintained by a brake on the drum. With such an arrangement all the movements used in the various methods of soaring could be learned without any great danger before any extended flight was attempted.

It is not improbable that large contrivances for soaring could be built where all the changes of the different parts were made by some other power than that of man; but when it is remembered that few winds blow with a constant force, and that gusts and calms follow each other too rapidly to be used by those of great size, it is only logical to predict that the limited durations of the gusts would have much to do with circumscribing the size of an effective machine.

BIRDS' METHODS OF STEERING.

The flight of birds still presents several unsolved problems. How they steer has never been fully explained. With the naked eye, or, still better, with a field glass, many of them can be seen to use their tails, lowering the left or right side according to the direction in which they wish to go. This use of the tail as a rudder is much practised by pigeons, jackdaws, rooks, larks, swallows, housemartins, sandmartins, and, I believe, by most of our common birds. Gulls let down a foot on one side or the other, and, no doubt, many other web-footed birds do the same. Still a rook or pigeon that has lost his tail manages to steer well, the chief result of the loss being that he cannot stop suddenly nor float upon the air, but must take rapid strokes with his wings. What other method, then, has the bird of steering? One fact that bears upon this question can be easily observed. When a bird wishes to turn to the left he moves the center of gravity of his body and flings himself on his left side, the right wing pointing upward and the left downward. How does he throw himself into this position? Most writers say that it is by striking harder with one wing than the other. In turning to the left the right wing would give a vigorous stroke, and so raise the right side of the body more than the left. At first sight it seems as if this explanation could not be the true one, since after a hard stroke the right wing should be lower than the left, which has only given a gentle one, and yet it is the right wing that is raised. But we must not be too hasty in drawing conclusions from this. When the down stroke takes place the wings do not descend far; the body rises so that the end of the wing appears to have described a much greater arc than it has done in reality. If, then, with the right wing a much harder stroke is given than with the left, the right side of the body will at once be raised, and the whole bird will be thrown upon its left side, while the movement of the wing itself may not be enough to be perceptible. If birds are watched as they fly, one wing seems always to be at the same angle to the body as the other, so that a straight line connecting the tips of the wings would pass through the two shoulder joints, or be parallel to a line passing through them. Instantaneous photographs of birds on the wing seem to me to bear this out. One wing may point up and the other down, but that is through the swaying of the whole body to one side or the other. In spite of this there may be an inequality of stroke that escapes detection, and without assuming this it seems on first thoughts difficult to account for the extraordinarily rapid turns made, for instance, by the swallow. But supposing that what appears to be the case is really so—viz., that equal force is put into both wings, there remains another possible explanation of this movement of the center of gravity to the left or right in turning. If a bird wishes to steer leftward, he may bend at the waist toward the left. So much has been said about the rigidity of the bird's backbone that its suppleness at a point just anterior to the ileum has been overlooked. I find that a swallow's vertebral column will bend at this point so as to form an angle of 150°; in the case of a kestrel it is 156°; of a tern, 155°; of a sandmartin much the same as in the case of the swallow; in the case of a duck, 165°—*i.e.*, a duck can bend much less at

the waist than the other birds mentioned, and you have only to watch ducks on the wing to see that they are very poor steerers. This is but meager evidence, and, at present, I have not the means of collecting more. Still, as far as it goes, it seems to show that suppleness of waist goes along with the power of swerving rapidly, and, *a priori*, it seems extremely improbable that such a highly acrobatic feat should be performed without calling into play every power that is available. Direct observation can, I fear, afford little help, since the feathers obscure any slight bend in the back. But the habit that many birds have—it can be easily seen in the case of gulls—of turning their heads in the direction in which they wish to go, suggests that it may be by bending the vertebral column at a point where it would be more effective, that they make their turns, just as a skater changes edge and flies off on an opposite curve by swaying the weight of his shoulders across to one side or the other, a change of balance effected by a bend sideways at the waist. It is certain that birds do not depend entirely on movements of the head or neck, since gulls, for instance, may occasionally be seen to turn to the left while looking to the right and *vice versâ*, a point which may be made out from instantaneous photographs. I cannot help thinking then, that a bird avails itself of the suppleness of its waist to alter its balance when it wishes to turn. Whether this is the sole means, or whether at the same time the wings are worked unequally so as to conduce to the same end, is difficult to decide. I may add that I have found the required muscles at the waist considerably developed.—*Nature.*

BIRDS' STEERING METHODS.

In response to the above, Mr. F. A. Lucas, of Washington, D. C., has written to *Nature*, that the statement that gulls sometimes steer by dropping one foot seems hardly tenable, for so small a rudder acting on so thin a medium as air would be of little effect. "And although I have seen many gulls under very varying circumstances, I have never seen them even appearing to direct their course in such a manner.

"That birds, to a great extent, steer by changing the position of their center of gravity is undoubtedly correct, and it is especially true of birds with long narrow wings, such as the petrels and sheerwaters. The albatross exhibits this method to perfection, and any one who has watched this bird circling far and wide will have noticed what an angle the outstretched, almost motionless, wings make with the level of the water, an angle frequently as great as 45°.

"The flexion of the body is, I take it, of comparative little help, difference in force or direction of wing stroke being the main method by which birds direct their course.

"The wings may act synchronously, a change in the direction of one wing causing it to act with more or less force than the other, while such change might be so slight as to elude the eye, or even a camera. A humming-bird will hover about a cluster of blossoms, now hanging motionless, now circling right or left around the flowers, and as there is no turn of the head or swaying of the body, it is evident that the directed force lies in the wings, although their presence is indicated by a mere hazy blur. The body is usually held at an angle of from 30° to 45° with the vertical, and the tail is kept closed, being indeed rarely spread, except when the bird is darting about in the air.

"The use of wings is well shown by the crows, which in fall and winter roost in great numbers on the other side of the Potomac, and may be seen toward sunset winging their way homeward from their feeding places. When the wind is light, the crows fly high and steadily, but in windy weather they may be seen beating back, just skirting the tree-tops, apparently to take advantage of any favoring eddy that may exist near the earth. As the birds dart up and down, and from side to side, one can clearly see the wings open and close, and unless my eyes are very deceptive, the two wings are by no means always opened to the same extent. The principal use of a bird's tail seems to be to effect vertical changes in direction, and while birds with moderately long tails usually have a more graceful, gliding flight than their abbreviated relatives, they are no more expert on the wing. The flight of the forked-tailed swallow is more pleasing than that of the short-tailed chimney swift, but the swift is quite as much at home in the air as is the swallow.

"Birds with unusually long tails, such as the hornbills, are apt to be but indifferent flyers."

From Russia to France.—A French aeronaut is to endeavor to reach Russia from France in a balloon. Given a favorable wind, there is nothing wonderful if the venture is successful.

EXPLORATION OF THE UPPER ATMOSPHERE.

By N. de Fouvielle.

In a recent issue of *Nature* there was an article on the Bombardment of the Sky, giving a *résumé* of the explorations of the upper atmosphere. In accordance with a letter from the Secretary-General of the Congress on Aerial Navigation, I wrote to M. Hermite to learn the result of his experiments, and why they had been apparently discontinued.

He has now several pieces of apparatus which he has had made at his own expense, and with which he hopes to obtain results of such a nature as to attract the attention of the scientific world. It is the delicacy required in the manufacture of these pieces of apparatus that is the sole cause of the delay.

Great honor is due to M. Hermite for his persistency in this direction, for no one before him had so much as made an attempt to reach these great elevations, being deterred by the fear that it would be impossible to recover the balloons; but the experiments that have been made prove this fear to be unfounded, since, in a civilized country like France, the return is easily secured even from the fastnesses of the mountains, whither one had been driven by the winds.

The following is a detailed account of the experiments of M. Hermite: Since the wonderful ascension of the *Horla* to the height of 23,294 ft. on August 13, 1887, by MM. Jovis and Mallet, no ascension to a great height has been attempted. The exploration of the upper atmosphere, however, is of a scientific interest of the first order, and will go far toward solving a multitude of problems. In order to exceed the limits which have heretofore been attained, the courage of the aeronauts hurls itself against difficulties which are almost impossible to overcome. In fact, the inhalations of oxygen by M. Paul Bert to overcome asphyxia, and used for the first time in that well-known and fatal ascension of the *Zenith* to a height of 28,216 ft., is an insufficient and incomplete means of maintaining life in these inhospitable regions. Closed and heated cars, in which the explorers shall be enclosed, have been proposed, but when we consider the expense of construction of a balloon equipped in this way, so as to exceed an altitude of 32,800 ft., it is not at all astonishing that it has not yet been put into execution. There nevertheless does exist a very simple means of reducing by enormous proportions the amount of aeronautical material by doing away with the aeronauts themselves, and of sending with simple little balloons some light instruments which, when they have returned to the earth and been found again, will show us what has occurred in the heights of the earth and ocean whither they have been sent.

This idea was promulgated by M. Claude Jobert in 1873, but has not yet been put into practice. Nevertheless, during the year 1892 M. Hermite made a series of experiments for the sake of accomplishing this object, in which he attempted to eliminate successively the difficulties which presented themselves. The first question to be solved was, Will we be able to find the balloons again which have been confided to the atmosphere? Will they not be carried by the upper currents at an enormous velocity and fall into desert lands or into the sea? Will we be able to recover the balloon and instrument intact that have fallen into the hands of people that are curious or ignorant? Experience alone can solve this problem. So while always busy in designing a very light registering apparatus, M. Besançon took it upon himself to construct small balloons of different cubic capacity and different substance, intended for these first attempts.

In the month of March, 1892, they started out almost every day several balloons provided with a circular of questions which contained their addresses, and which is reproduced below.

Ascension of balloon ....
Started from ....
The ....at ....hr. ... ..min ....

NOTICE.

Whoever shall find this card is requested to send it to the mayor or the comptroller of the nearest commune and to fill out as far as possible the questions given below, and to send it without breaking it to the address on the opposite side.

Question No. ....Descended at ....hr. ....min. ....
1. At exactly what point did this card fall? .... Commune of .... Department of ....
2. At what time was it found? .... hr. ....min. ....
3. Has the balloon been seen? If it were seen, at what hour?
4. What was the temperature at the time the balloon passed?

5. What was the height of the barometer?
6. What was the weather and what was the appearance of the sky?
7. What was the strength and direction of the wind?

PERSONAL REMARKS.

....
....

Signature and address { ....
....
....

These balloons were sometimes provided with automatic distributors of cards in order to determine the velocity and the direction of their course. Several were returned, and they have given interesting results, to which we will refer later. It is sufficient to say here that the results were far better than was expected. About half of these little balloons, whose cubic capacity did not exceed a yard, were found again, and all fell at a distance from Paris comprised within a radius of 93 miles.

The second question to be solved was, What are the conditions to be fulfilled by a balloon in cubic capacity and construction which is suited to reach the maximum altitude? Theoretically, in order that a balloon may reach, for example, a height of 18,000 ft., where the barometric pressure is reduced by one-half, it is necessary that one-half inflated it shall be able to rise. To reach a height of 28,800 ft., where the pressure is reduced to one-third, it is necessary that it shall be able to rise when one-third inflated, and so on. Practically, however, this will not be the case, for if a balloon is given a very slight ascensional force the slightest additional weight will prevent its ascension. The causes for extra weight would be the escape of gas, cooling, and a deposition of dampness on the covering of the balloon.

By careful construction and choosing proper materials for the construction of the envelope, the factor of the escape of gas can be avoided; but the two other causes depend on meteorological circumstances, and are independent of human control. To be sure, we can put the chances on our side by choosing a clear sky, but it is desirable that these explorations should be frequently renewed. It was necessary to determine, then, whether a balloon of predetermined capacity is on the average capable of crossing the snow zone, which is the true barrier against which the frail waifs of the air are compelled to hurl themselves if they are not furnished with sufficient force to cross it.

From experiments which were made on large balloons, the deposit of dampness which can occur on their envelope amounts to .25 oz. per square foot, a weight corresponding to a thickness of liquid water of .01 of an inch. Then, admitting that the diminution of the temperature of the gas of the balloon will amount to 54° F., the result will be a practical increase of weight of .02 oz. per cubic foot, for a balloon inflated with hydrogen, and .062 oz. per cubic foot for a balloon inflated with illuminating gas.

M. Hermite has taken as a typical envelope, triple goldbeaters' skin, which offers the advantages of strength, lightness, and almost absolute impermeability. Nevertheless, he has also obtained good results with a paper weighing .02 oz. per square foot. Wishing to keep within practical limits, and not enter the domain of fancy, he has not thought it advisable to make balloons of a greater cubic capacity than 147,000 cub. ft., for beyond 15.5 miles it is necessary to increase them to enormous proportions in order to gain a few miles. We can therefore fix on from 15.5 to 18.6 miles as the limit of aerial exploration by means of balloons. It now remained to put theory into practice, and the beginnings were not fortunate.

(TO BE CONTINUED.)

THUNDERSTORM PHENOMENA ON THE MATTERHORN.

In 1888–89 I witnessed some 28 thunderstorms on the Pampas of South America; and came to the conclusion—

1. That there was no reason to suppose that the so called "sheet-lightning," or "summer-lightning," is anything more than the glare of distant spark-discharge.

2. That by far the greater number of discharges took place between different layers of cloud, and not between clouds and the earth.

3. That the origin of these storms lay in the electrical excitation due to the friction between opposed currents of air (carrying cloud), upper and lower respectively.

This year I was witness of a thunderstorm under very different circumstances, and I observed a phenomenon that appears to me to be of interest.

On July 10 I was on the Matterhorn in very doubtful weather. It appeared as though the Föhn (or southerly wind) were struggling with a northerly wind, and as though the former conquered. Clouds or mist pressed up from Italy, and rose higher and higher, covering the other mountains before the Matterhorn. We had some snow at intervals even before midday, and by the time that we had, on return from the summit, descended as far as the upper hut, it was snowing steadily. I think that, as regards the Matterhorn, the electrical hissing of ice-axes, rocks, etc., began about 3.30 P.M. or 4 P.M., and lightning began rather later.

At last came one flash, apparently very near to us, the thunder following close with a crash. *Before the thunder*, however, and apparently *with* the flash, came a curious splitting, cracking, and shivering sound, with a kind of "splash" from the rocks—as it seemed. I give many adjectives for want of one good expressive word. This sound preceded the thunder, and was both sharp and faint; I felt that I only heard it because I was on the spot.

Later, another flash came close to us. This time I heard no "splash" from the rocks; but, apparently *with* the flash, and before the thunder-crash, there came a light, shivering, branching crack again, something like the "ghost" of thunder, one might say. It reminded me this time of the shiver that passes over the surface of new snow, only very slightly crusted, when first broken in any part by the feet of a traveler. (Some climbers will know this sound; but I myself have only occasionally noticed it, and that only when I have been the first on a snowfield soon after a heavy fall of snow.) I received a slight shock in the head this time. A third flash gave the same sound as the second; but no others seemed so close, and I never heard this sound again.

It was dark when we reached the lower hut; and all down the arête the brushes of purple light that streamed from our fingers (when held up) and from our axes, hats, hair, etc., were very beautiful. The fingers gave better brushes when wetted. There were numerous brushes streaming from the rocks, these being wet with water melted from the snow.

Some other people who were on the Gorner Grat the same day told me, before I mentioned my experiences, that the lightning seemed to give a splashing sound on the rocks. They also told me that those who wore felt hats, felt return shocks, while those with straw hats did not. All the hats were wet.

So much for observation; now for a theory.

To begin with, since the thunder distinctly crashed *after* the lightning-flash, it would seem that the phenomenon that caused the sound I heard must have preceded the spark.

I would suggest the following explanation.

I do not think that those who have never been actually in a storm realize how very indefinite, in substance and boundaries, "a thundercloud" is. It seems certain that we must not regard it as if it were a polished conductor that is gradually charged until it sparks to earth or to other clouds. More probably there is a fall (or rise) of potential through the substance of the cloud itself. When the stress is too great, there is probably a breakdown along many paths in the form of the fine branching sparks observed when a Wimshurst is used without a condenser. This preliminary breakdown suddenly gives a very much larger potential difference between the portion of the cloud-masses toward which it takes place; so suddenly in fact, that a spark-discharge occurs before more diffuse modes of readjustment can obtain. It seems to me that it is only by some such preliminary discharge from behind that such irregular "surfaces" as those of clouds could attain the condition requisite for the true spark. In something the same way we can pass a spark between two rough or pointed metal terminals by a sudden discharge through them, while we could not raise them in any slower way to the necessary condition.

According to this view, a slighter and more branching discharge in the body of a cloud would be the necessary preliminary to a regular flash; and the, relatively faint, sound of it would precede the "thunder" of the final flash. When once the flash occurs, resistance is much diminished, and the stress of the whole region is relieved through the path created.

An obvious objection to this view, however, will occur to many. "Would the time-interval be long enough? Would not the first sound be practically heard with the thunder, and be drowned in it?"

Another explanation might be, that (as is often the case with a Wimshurst or other machine) there are fainter, tentative, branching discharges that precede the bright spark. But, if this were the case, they should surely be heard in some cases before any spark occurs at all.

Finally, the sound, though it appeared to come out of the

air, might have been due to the movements of the stones and rocks over the surface of the mountain, occurring when the stress was relieved. Such a sound might well reach one before the sound of the spark.—*Walter Larden, in Nature.*

NOTES.

A New York Ascension.—Captain Emile Carton, the French aeronaut who, with Miss Juliette Rode, of Stapleton, S. I., made a balloon ascension on Saturday evening from Lion Park, had a safe descent the same night on Desert Island, off Lawrence Station, on the Long Island Railroad, 28 miles from New York. This was Captain Carton's one hundred and sixth balloon ascension, and he hopes to make a thousand more, he says, before he dies. It was Miss Rode's second balloon trip, and she says she is willing to make a hundred more.

A Thrilling Balloon Ride.—On September 22, being State Commissioners day, special preparations were made by the World's Fair Directors to attract crowds to that part of the grounds. One of the amusements arranged for was a balloon ascension by an old and experienced aeronaut, Professor King, of Philadelphia. A large balloon was inflated in the space between the New York State Building and the Fine Arts Building. It was equipped for a short ascension, Professor King believing that with the easterly winds which prevailed during the afternoon he would be driven back of the city, and could land on the open prairie within a short time after he had risen from the earth. The time set for the ascension was 3 o'clock. It was three-quarters of an hour later before the start was made. While active preparations were going on a great crowd assembled around the balloon. Among the number was Miss Joie Morris, whose home is at Ames, Iowa, but who came here this summer to see the World's Fair, and who had secured a position in the Fine Arts Building, where she sold catalogues. Miss Morris watched the aeronaut as he made ready for his trip and became possessed with an insane desire to make the journey into the clouds with him. She sought an introduction to him and preferred her request to be allowed to be his companion in his aerial flight.

Professor King objected very strongly at first to taking the young girl with him, but her pretty and persuasive manner finally won him over, and he agreed to let her go. The weather was so fine that the ascension seemed like child's play to the veteran aeronaut. When all was ready he and Miss Morris stepped into the frail basket, and the word was given to cast the big gas bag loose. It rose quietly and impressively straight toward the blue sky, and the thousands and thousands of people who were packed in a black mass on the wide street and plaza before the New York Building gave a mighty cheer and a mighty cry of "Bon voyage" as the travelers went upward.

For a short time everything went well with the voyagers. A strong but gentle wind blew the balloon toward the southwest. As it continued to rise the occupants of the car could be seen waving their hands to the people on the Fair grounds far below them. When the balloon had reached an altitude of about 1 mile it struck a counter current of air, which changed its course to the northeast. It was a stiff breeze, and the balloon quickly forged toward Lake Michigan. The revenue cutter Andy Johnson put out after them, and, after a long chase, rescued the aeronauts as they were being dragged over the water.

Rain-Making.—*The English Mechanic* says that experiments in rain-producing are still being carried on in various parts of America with more or less success; but they may be discontinued if it is true that a man was killed by the artificial lightning, and that his widow is to sue the experimenter for damages. Rain-producing is carried on in some parts with balloons which carry up a cartridge of dynamite, which is exploded when the time fuse has consumed the allotted length. At Hartford, Conn., an accident was averted the other day by the experimenter tearing the cartridge out from a balloon which had got on fire, and would not rise as it should have done.

A Thrilling Balloon Trip.—On September 8 William Sayres, 20 years old, was assisting in the preparations for a balloon ascension in Wheeling, W. Va. Just as the balloon started skyward one of Sayres's feet became entangled in the ropes between the balloon and the parachute. Thousands of spectators saw the young man carried into the clouds hanging head downward and in danger of dropping at any moment.

He succeeded in getting hold of one of the ropes, and drew himself up to the rim of the balloon, where he clung until landed safely on the Ohio side of the river. It was Sayres's first balloon trip.

Balloon Manœuvers.—An interesting trial with dirigible balloons has just taken place at Paris. Five military balloons, with aeronauts in charge, were sent up from the Esplanade des Invalides, with instructions to descend within an hour at Combs la Ville, after sailing over a radius of nearly 30 miles, supposed to be occupied by an enemy. As the balloons made their ascent, a contingent of cyclists were despatched from the same point, with orders to capture the balloons should they fail to alight beyond the boundary of territory agreed upon. Of the five balloons, two landed safely on friendly ground; a third pursued its obstinate career as far as Reaux; and the remaining two fell within the radius, and succumbed as prisoners to the cyclists.

Edison on Flying Machines.—"Once I placed an aerial motor on a pair of Fairbanks scales and set it going. It lightened the scales, but didn't fly. Another time I rigged up an umbrella-like disk of shutters, and connected it with a rapid piston in a perpendicular cylinder. These shutters would open and shut. If I could have gotten sufficient speed, say, a mile a second, the inertia or resistance of the air would have been as great as steel, and the quick operation of these shutters would have driven the machine; but I couldn't get the speed. I believe that before the airship men succeed they will have to do away with the buoyancy chamber."

A New Military Signaling Balloon.—Mr. Baden Powell, of the Scots Guards, has, it is stated, devised a new method of signaling by night with the aid of a paper fire balloon of 6 or 8 ft. in diameter. When it is desired to send a message, some beads made of a brilliant quick-burning composition, are strung on a piece of quick-match, leaving intervals, and using large and small beads to make the corresponding flashes. The balloon is inflated by burning spirit or even straw or wood. The message string is then suspended below it, a time fuse attached, and the balloon being sent up, the message is flashed forth. The apparatus is described as very portable; one man can easily carry it, and with it not only can one preconcerted message be flashed, but a few words can be sent up at one time, and those can be answered from a similar balloon from another part, upon which other balloons can be employed to continue the signaling.—*St. James Gazette.*

Phillips' Flying Machine.—A few evenings ago this machine was run, and completed a flight of over one and one-half turns round the track, or a little above 1,000 ft., without touching. The speed on this occasion was timed almost exactly at 40 miles an hour. There was a dead weight of 55 lbs., and the machine itself weighing 330 lbs.; the total weight lifted was 385 lbs. A new set of sustainer surfaces had been substituted for those originally used, and the pitch of the propeller was somewhat reduced in order to get a higher speed, for which the sustainer surfaces were suited. The slats in this case are not quite horizontal when the machine is at rest, but when in the flying position the surfaces are nearly horizontal. We understand that on another occasion three complete rounds of the track were made, the machine being in the air the whole time; that was on a perfectly calm evening. The difficulty of working what is practically a model machine will be appreciated by all those who have made experiments with very small steam engines and boilers. In the present case there is no more than two or three double handfuls of coal on the grate at one time. Another difficulty arises from the centrifugal action due to the machine being confined to the circular track. This is more especially apparent at the higher speeds, when the fire is apt to get all thrown to the outer side of the grate bars, thus letting cold air through and reducing the pressure.—*Engineering.*

Professor Bell on Aerial Navigation.—In the course of an interview with Professor Alexander Graham Bell, of telephone fame, in Montreal recently, he is reported to have declared his belief, amounting almost to conviction, that the flying machine would be an accomplished fact before the end of the century, at most before the end of ten years. This great undertaking, he said, was no longer in the hands of "fakirs;" it was engaging the minds of practical scientists, like Maxim, the inventor of the Maxim gun, and Professor Langley of the Smithsonian Institution. The great difficulty in the past was that inventors were on the wrong track. They had been vainly trying to make a flying machine on the principle of the balloon, lighter than the air. Such a machine could never be properly steered. The flying machine of the future would have greater specific gravity than the air. Of this Professors Langley and Maxim were convinced, and on this principle one or both will soon succeed. The machine need not have wings. Nature was not always a wise guide; the steam locomotive got on well without legs. Indeed, the rotary motion was the most economical.

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[Formerly the RAILROAD AND ENGINEERING JOURNAL.]

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CONTENTS.

INDEX TO ADVERTISEMENTS.

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ALPHABETICAL INDEX TO ADVERTISERS.

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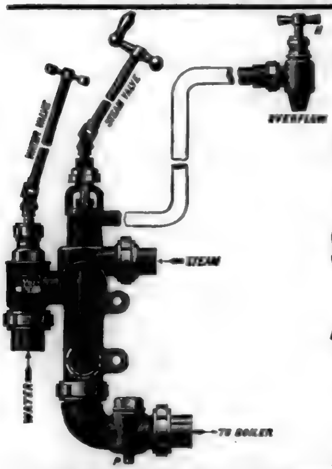

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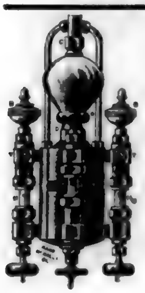

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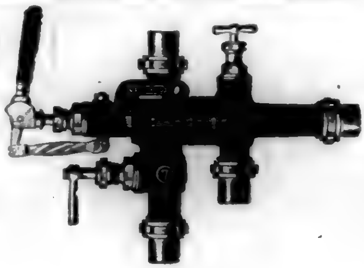

AMERICAN ENGINEER AND RAILROAD JOURNAL.

(Formerly the RAILROAD AND ENGINEERING JOURNAL.)

PUBLISHERS' DEPARTMENT.

THE WORLD'S RAILWAY.

MAJOR J. G. PANGBORN, who has been the active and presiding genius to whom the credit for the splendid exhibit of the Baltimore & Ohio Railroad at the Chicago Exhibition is due, announces an *édition de luxe* of his forthcoming volume upon the World's Railway. The book is to have 160 pp., 11 × 14 in., and will be printed on hand-made imperial Japan vellum paper, the binding to correspond.

This work complete, it is said in the announcement, "will, in its illustrations and text, present the results of extended personal study and research in Europe as well as in America in perfecting the exhibit, which the unanimous award of the jury representation of various nations declared was unequalled in completeness and in value by the possessions of all the museums and institutions of the world combined.

"The publication will," it is further said, "present for the first time in clear, logical, and chronological order the history and development of motive power, including many illustrations of locomotives hitherto unknown in any book extant. The same will be true as to early equipment and track, and while it is not the intention to make the book a technical one, the text, combined with the pictorial representations, will convey a thorough understanding of construction."

All who are interested in the wonderful development of railroads during this nineteenth century will look forward eagerly to the publication of this interesting volume.

General Notes.

The Lehigh Valley Creosoting Company, of Jersey City, have removed their office from Jersey City to Rooms 136 and 137 Washington Building, No. 1 Broadway, New York.

Norton's Ball Bearing.—Mr. A. O. Norton, of Boston, announces that he has received the highest award at the Chicago Fair for the Improved Ball Bearing Lifting Jacks which he manufactures.

A Railway Across Guatemala.—The first section of the Oceanic Railway, to connect the Atlantic and Pacific coasts of the republic of Guatemala, from Port Barrios eastward, is approaching completion. The second section is now under survey, and the government intends to shortly commence constructing a section starting from the capital.

Large Tank Steamships.—The largest tank steamship in the world, the *Batoum*, is owned by the Standard Oil Company, and has a tonnage of 4,058, with a capacity of 2,700,000 gallons of oil, and more than 7,000 barrels in bulk—that is, 80,000 galls. more than the next largest vessel of her class afloat. The same company had recently launched for them at Roach's shipyard another tank ship, which is 230 ft. long, 17 ft. beam, and 19 ft. deep. Her capacity is 760 galls. of oil in bulk.

Pedrick & Ayer.—From the assignee of this firm in Philadelphia we learn that the shops are now running 10½ hours per day, with about half the regular force, and have sufficient orders coming in to keep that many men employed. The business is being managed by Mr. James M. Hibbs, as assignee, pending the formation of a new company, of which Mr. Pedrick will be one of the largest stockholders, Mr. Ayer going out and Mr. Pedrick remaining in to manage the mechanical part of the business, as heretofore.

Welding Rails.—The Johnson Company, at Johnstown, Pa., have been experimenting for some time with electrically welded rails, to be used in long lengths. The method is to lay the rail in position and then bring the machine to the joint to be welded. It is said that at a recent test the machine was stopped over a joint, and in less than a minute after the current was turned on the rails at the ends began to change color, and inside of three minutes the iron was raised to a white heat. The ends were then brought together under pressure and a perfect weld made.

The Stirling Company's Boilers.—This Company announce that they have received the "highest award" for their boilers at the Columbian Exhibition, and further that "the constant and uninterrupted service night and day rendered by the 2,800 H.P. of our boilers in use at the Fair from May 1 to November 1 were for the Stirling boiler the unqualified approval of all members of the Executive Board."

The following recent sales are also announced: to the Providence Union Railroad, 1,000 H.P. in four units of 250 H.P. each, and the American Straw Board Company, 975 H.P.

Riehle Brothers.—This firm report decided indications of an improvement in business, as the following recent orders received by this firm indicate: 20,000-lb. horizontal testing machine, 10,000 lb. vertical screw-power testing machine, canvas testing machine for the United States Government, warehouse and railroad trucks for export, 3,000-lb. transverse testing machine, 1,000-lb. cement testing machine with worm gear, "Star" cement testing machine, 40,000-lb. screw-power testing machine, two 1,000-lb. cement testing machines, 100,000 lb. testing machine, six 20-ton Riehle-Robie protected ball-bearing screw jacks.

The Linden Steel Company.—The assignee of this Pittsburgh Company has been discharged by order of the court, and the plant is now in operation. How full the works will run will depend on the condition of trade. At present only the blooming mill, one 10-in. mill, hammers, and sheet mill making Linden patent steel floor, plates are running. This Company is manufacturing the Linden Steel Floor Plates, which are rolled with projections of ribbed, checkered, or diamond form, and are used for floors and steps in fire-rooms, running-boards on locomotives, car-steps, and for general use wherever roughened surfaces are required on walks or places likely to be slippery or subject to much wear.

Exhibition of New Inventions in Copenhagen.—A number of circulars have reached this office announcing a special exhibition of such new inventions as may be considered likely to be used in Denmark, Norway and Sweden. The exhibition will be held by the Industrial Society of Copenhagen at the initiative and with the co-operation of "The Copenhagen Patent Office." It is said further that the specialty of "The Copenhagen Patent Office" is the sale and utilization of patents and inventions for a suitable commission. In other words, this patent office appears to be a patent agency, and not what its name might imply. Intending exhibitors would probably do well to make careful inquiry before incurring any obligations or expense in connection with this exhibition.

The J. A. Fay Company, of Cincinnati, received for their wood-working machinery a grand award, as follows:

"Medal and diploma for machines of advanced and superior construction, showing strength and elegance in the design, utility and compactness in the arrangement of the parts, for the general accurateness of workmanship and finish of all the tools shown."

THE Chairman of Awards Committee made the following recommendation with reference to the Egan Company's exhibit:

"I recommend the issue of medal and diploma for the well-selected display of a series of wood-working machines of advanced modern construction in the whole and detail of parts shown, as well for their perfect working and action, and in addition thereto for their finish, which is in accordance with the highest state of the art."

The Electric Heating of Street Cars.—The electric heating of trolley street cars has become an important branch of the business of the Consolidated Car-Heating Company of Albany. Such electric heaters with regulating switch have been applied already to cars in 29 cities and towns throughout the United States and Canada.

From the Rochester Railway has recently been received a second order; from the Union Railway, New York, a third order; and from the Albany Railway a fourth order for such equipments. The Union Railway, New York City, and the Albany Railway have all their cars now equipped with the Consolidated Company's electric heaters and regulating switch.

This Company has received awards at the World's Fair for the Sewall Steam Coupler, the Multiple Circuit Hot Water System, the Improved Commingler Hot Water System and their Direct Steam System.

Link-Belt Machinery Company.—The use of rope as a substitute for leather belting or line shafting, in the transmission of power, seems to grow more and more into general

favor by the power users in the United States. The Link-Belt Machinery Company, of Chicago, who were the first to introduce into this country rope power transmissions employing grooved iron sheaves, have recently filled the following orders: The Standard Oil Company, of Whiting, Ind., were recently furnished a rope drive for distributing the entire power in their new barrel house. A rope transmission was also designed and erected for the Lawson Varnish Company, of Chicago, which is to drive the machinery in their new plant on West Kinzie Street. The Mississippi Cotton Oil Company, of Columbus, Miss., George L. Thompson Manufacturing Company, Chicago, and G. Brulay, Brownsville, Tex., are recent purchasers of rope transmissions. The Racine Basket Manufacturing Company, of Racine, Wis., under date of October 4, in writing the Link-Belt Machinery Company regarding a rope drive furnished them, say: "The rope transmission obtained of you for our gang saw we have in operation. It is almost noiseless, and it does double the work we have been able to do with a belt put in its place."

An Index of Current Technical Literature.—It seems sometimes as though the knowledge which the human race was accumulating would ultimately become so great as to be useless, paradoxical as that assertion may seem. Every person who makes even a faint effort at keeping abreast of, or even to follow at considerable distance, the modern advance of knowledge, must have felt this. We have some subject or subjects in which we are interested, and begin to collect material relating thereto. Books, pamphlets, memoranda, papers, clippings, blue prints, engravings—scraps of all kinds soon begin to accumulate, until this quantity makes it impossible to make use of them. Or take almost any subject relating to the engineering of to-day. We start out with the task of making an exhaustive study of it. We begin by reading standard books; then we look into papers read before societies, and dip into technical literature, until we find that the great ocean is so vast and so deep that to measure it is hopeless. It seems, then, that some great labor-saving organization must be designed by which the immense stores of knowledge may be classified and made accessible. In other words, a great need of the present day, which is constantly growing more imperative, is the systematic indexing of human knowledge.

Therefore any effort to supply this great want must be hailed by all who are engaged in "handling" technical knowledge with delight. Such a reception should be given to De Land's "Synoptical Index of Current Technical Literature," which is now in its second volume, and of which the editor, Mr. Fred De Land, whose nest is in the Rookery, in Chicago, makes the following announcement:

"Commencing with the November number of *Electrical Engineering*, De Land's 'Synoptical Index of Current Technical Literature' will be broadened in its scope, and printed on separate leaves. Thus each leaf may be bound separately under the respective subject title, or the page pasted in a book, or the leaf cut in two and the two portions filed in a card indexing case. But one subject will be placed on each leaf, and the unoccupied portion left blank. Each leaf will be paged consecutively at the bottom of the lower half, and each section of each subject will bear a consecutive number, thus facilitating ready reference in any form of filing. Paper of heavier weight than heretofore will be used for this index, and the whole bound with cord."

This index may be commended to all who need a guide through the groves, which are rapidly becoming a tangled wilderness of technical literature. $3 per year.

Awards to the Safety Car Heating and Lighting Company.—This Company had two exhibits in Chicago—one of their system of heating and the other of their method of lighting.

As every reader of this paper is aware, for a good many years past American railroad companies have been trying to find some method of heating their cars in winter that should be at once safe, practical, and economical; but the difficulties surrounding the task have been very great.

It is now five years since the system of the Safety Car Heating and Lighting Company was first brought out, and it is already in use on 2,800 cars running on 48 roads in this country. This system received the "Highest Award," on the ground of "excellence of design and good efficiency of their direct steam-heating system, the combined hot water and steam-heating system, and for the design of the Gibbs coupler."

The system of lighting cars which the Consolidated Company exhibited was the well-known Pintsch system, which was originated in Europe, and about eight years ago it was introduced to this country, where it has made for itself a remarkable record. It is now applied to over 55,000 passenger cars in Europe, United States, South America, India, and Australia, and is adopted as the standard by many of the prominent railroads in the United States; also by the Pullman and Wagner Palace Car Companies. It has received numerous awards in different parts of the world, including the following:

Grand Gold Medal, Moscow, 1872.
Progress Medal, Vienna, 1873.
Gold Medal, St. Petersburg, 1875.
Society of Arts Gold Medal, London, 1877.
Gold Medal, Cincinnati, 1881.
Highest reward and Special Mention, Atlanta, 1881.
Gold Medal, Bordeaux, 1882.
Chicago, 1883, Gold Medal for "superior and most comprehensive compressed gas system for railways."
Berlin, 1883, Gold Medal, Hygiene Exposition.
London, 1883, Fisheries Exhibition, Medal.

To this list there must now be added the "Highest Award" at the World's Fair at Chicago. This award is given on the ground of "first-class workmanship and perfect and effective construction of all its parts." The "Pintsch" system is what is known as an "oil-gas" system. It has been fully demonstrated that it is a perfectly practicable system of illumination for the railroad service of the country. The light furnished is in no way experimental, but has been tested under every conceivable combination of circumstances.

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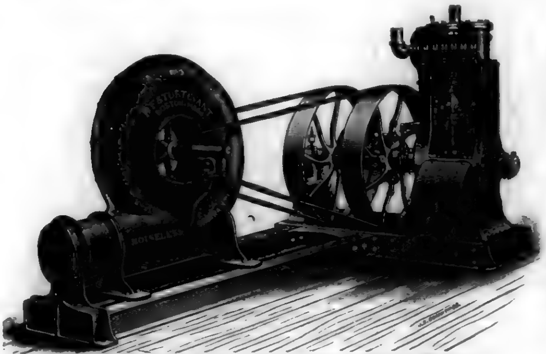

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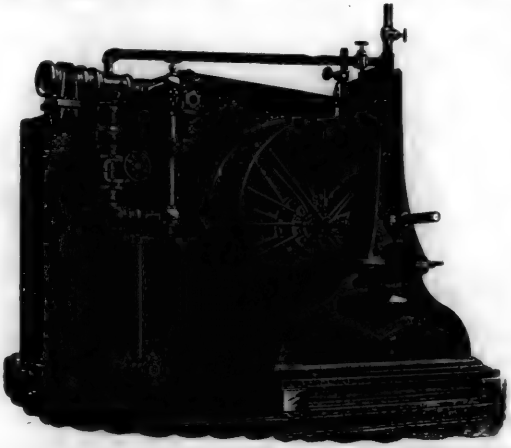

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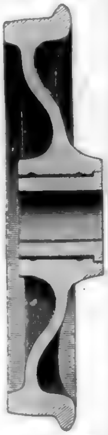

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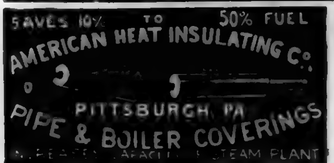

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